Giant Astro Software Buyer's Guide

ASTRONOMY

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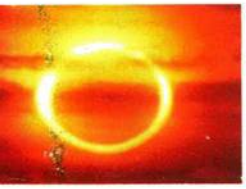
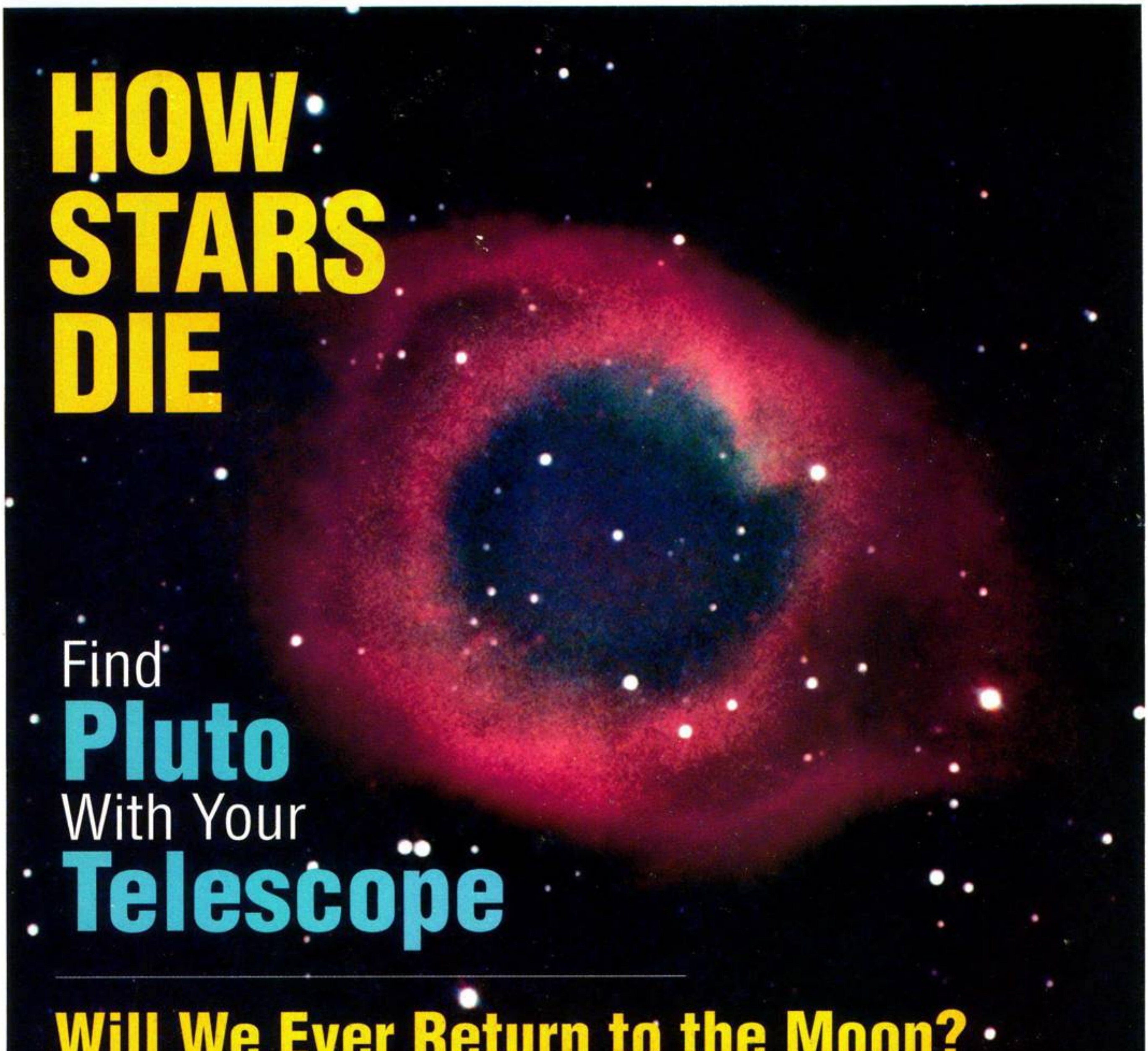


Eclipse Over North America



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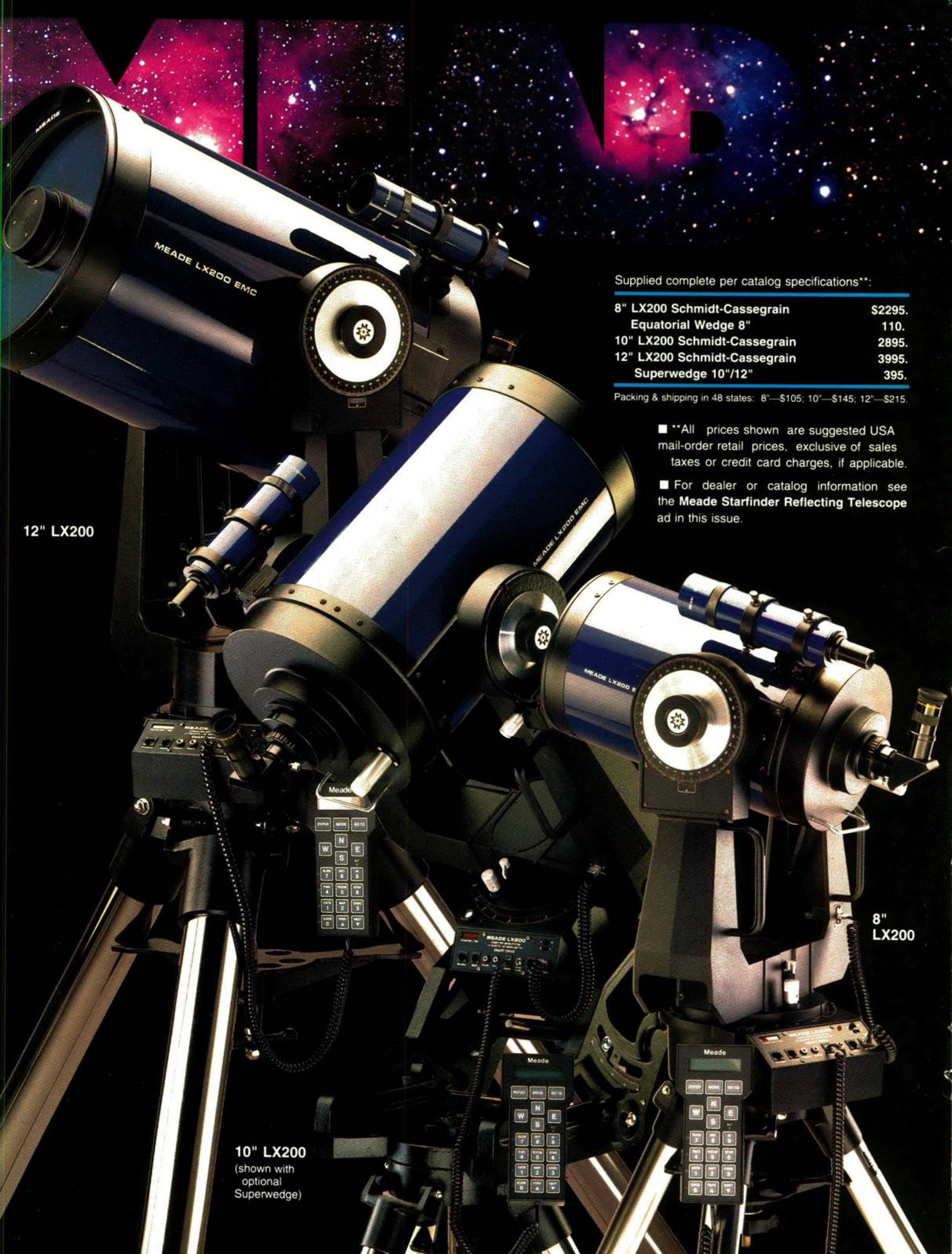
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- **All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

- For dealer or catalog information see the **Meade Starfinder Reflecting Telescope** ad in this issue.

12" LX200

8" LX200

10" LX200
(shown with
optional
Superwedge)

LX200 SCHMIDT-CASSEGRAINS:
New Technical Advances for 1994.

Six new technical advances that extend Meade's position at the leading edge of telescope technology:

1. 18-volt Dual-Axis Drive Systems—All Meade 8", 10", and 12" LX200's now include **18-volt DC power systems,** superseding the previous 12-volt systems, with the result that **LX200 motor torques are increased by about 60%** over previous models. Combined with new, more efficient DC motor electronics, these powerful, high-torque drives, on both telescope axes, yield a level of drive smoothness heretofore unavailable on any commercial telescope.

2. Ultra-reliable Electronic Systems—Recent electronic refinements in the main circuit boards, the hand controller, and in the control panel electronics have made Meade's new advanced LX200's more reliable than ever before. State-of-the-art improvements in microcircuitry, combined with *thousands* of hours of laboratory and field testing, result in **the most trouble-free serious telescopes ever manufactured.**

3. New *Version 3.20* Software—As recently announced, Meade *Version 3.20* software is the very latest in telescope operating systems and permits **quick (less than 10 seconds!) 2-star alignment** of the LX200 in the altazimuth mode, without requiring your latitude or longitude, without even leveling the tripod. Just use 2 easy-to-find reference stars and the telescope tracks and actuates GO TO with extreme precision.

*For safety reasons AC-powered personal computers should be used indoors only.

Meade 8", 10", and 12" LX200 Schmidt-Cassegrains include an RS-232 serial port (PC connector) on the power panel.

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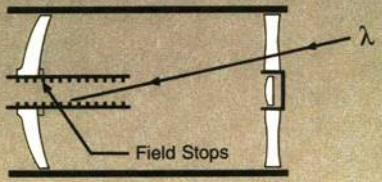
4. Software Library Options
Included with every LX200 is a basic 747-object database of the finest deep-space objects, reference stars, and the 8 major planets. *Version 3.20* LX200 software allows for two new optional object libraries:
—**Library Option 1:** An object database of **10,600** celestial objects taken from the Messier, NGC, and IC catalogs. Available at $99.**
—**Library Option 2:** An object database of **64,350** celestial objects, including the 10,600 objects of Library Option 1, above. Available at $149.**

5. PC-Interface Capability
Meade AstroSearch/200™ sky software permits the interface of a personal computer (PC) to your LX200. Just load Meade AstroSearch/200 software into your PC, connect the PC* to the LX200's PC port (located on the telescope's power panel) and you're ready to **point-and-click on any of 45,000 planetary, deep-space, or stellar objects** now visible on the PC display. As you point-and-click, the LX200 slews at high-speed (up to 8°/second) simultaneously on both axes, precisely centering the object in the field of view. **The Meade AstroSearch/200 celestial software package, supplied on 3.5" discs for Windows™ 3.1 or higher, is available from Meade dealers at $99.95**.**



Field-stops *(arrow)*, now included on Meade 8", 10" and 12" Schmidt-Cassegrains, significantly increase image contrast by effectively blocking off-axis stray light rays, λ.

6. Contrast-Enhancing Field Stops—All Meade 8", 10", and 12" Schmidt-Cassegrains now include a series of computer-optimized internal field stops, for greater rejection of unwanted stray light than ever before possible. These field stops, machined into the inside-diameter surface of the primary-mirror baffle tube *(see diagram)*, **significantly increase lunar, planetary, and deep-space image contrast,** compared to SCT's not so equipped.

Plus all of the features that have already made Meade® LX200's the largest-selling serious telescopes in the world:

- **Legendary Meade Super Multi-Coated (EMC) Schmidt-Cassegrain Optics** —The finest SC optics available, optics that yield razor-sharp stellar images and high-resolution observing of the Moon, planets, and deep-space.
- **Heavy-Duty Fork Mounts**—The largest, most rigid in the industry, complemented by large 4"-diameter polar ball bearings and by DC servo-motor-driven worm gears on both telescope axes.
- **Four-speed Drives on both Telescope Axes**—Including photo-guiding (at **2x** sidereal rate); image centering and microslewing in the main telescope (at **32x** sidereal rate); image centering in the viewfinder (at **2**°/sec.); or fast-slew of the main telescope across the skies (at up to **8**°/sec.).
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- **747-Object Built-in Library**—Enter any of the 110 Messier objects, 278 of the finest NGC objects, 351 stars (doubles, variables, reference stars), or one of the 8 planets (from Mercury to Pluto), press GO TO, and the telescope slews at up to 8°/sec., centering the object in the field.
- **Permanently Programmable Smart Drive™** —Capable of reducing periodic drive errors to 5 arc. secs. or less, an observatory standard.

Specifications: 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 SC optical tube assembly with super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; keypad handheld controller with digital readout display, PPEC Smart Drive, four-speed drive control on both axes, GO TO controller, and 747-object software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (DC capability for operation from auto cigarette lighter plug available optionally); 8 x 50mm viewfinder with crosshairs; 1.25" diagonal prism (8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (8", 10") or giant field tripod (12"); foam-fitted carrying case; complete operating instructions.

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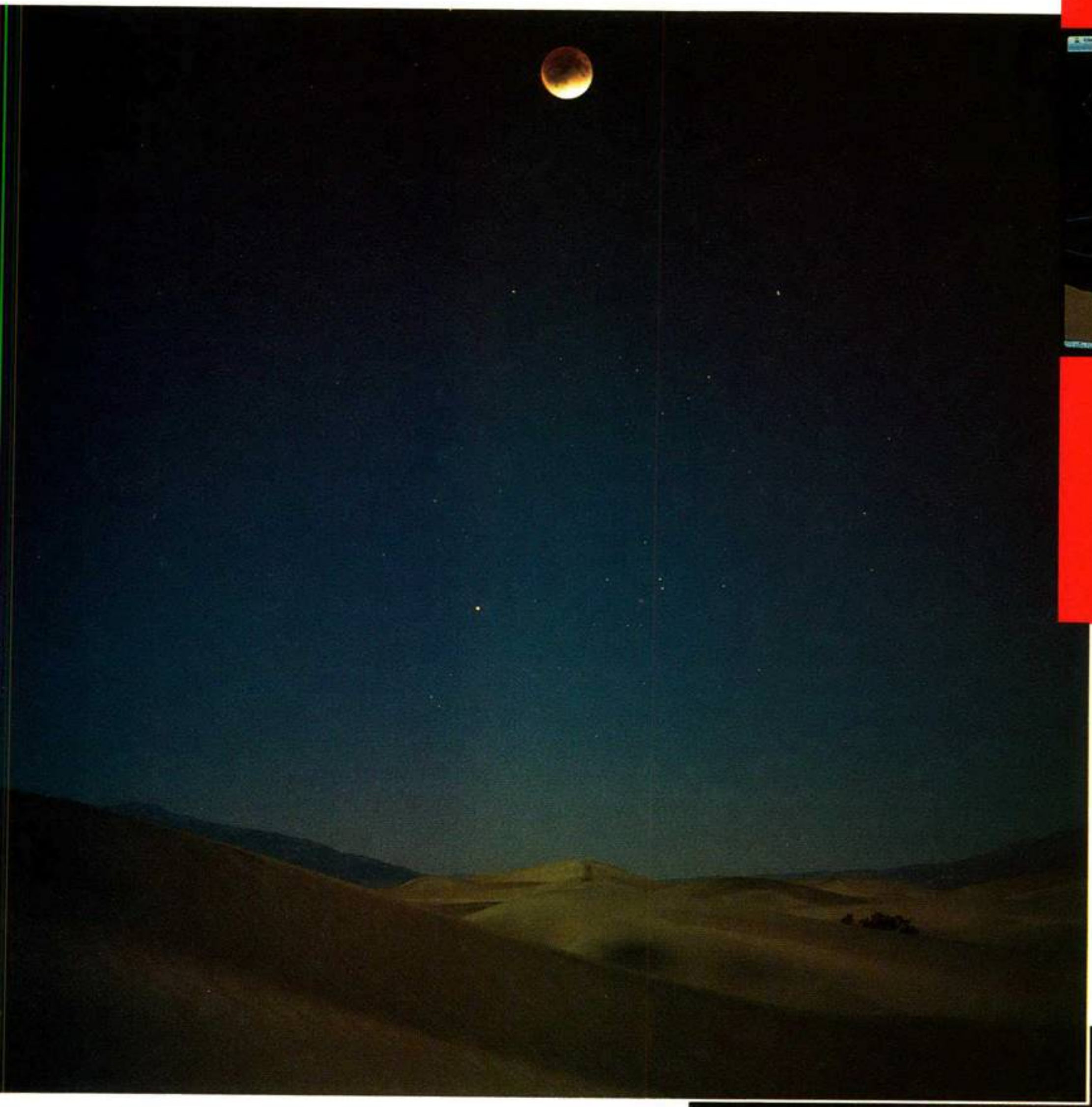
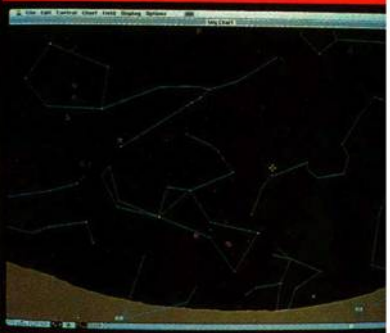
ASTRONOMY



Tom Bullock

SPECIAL INSERT



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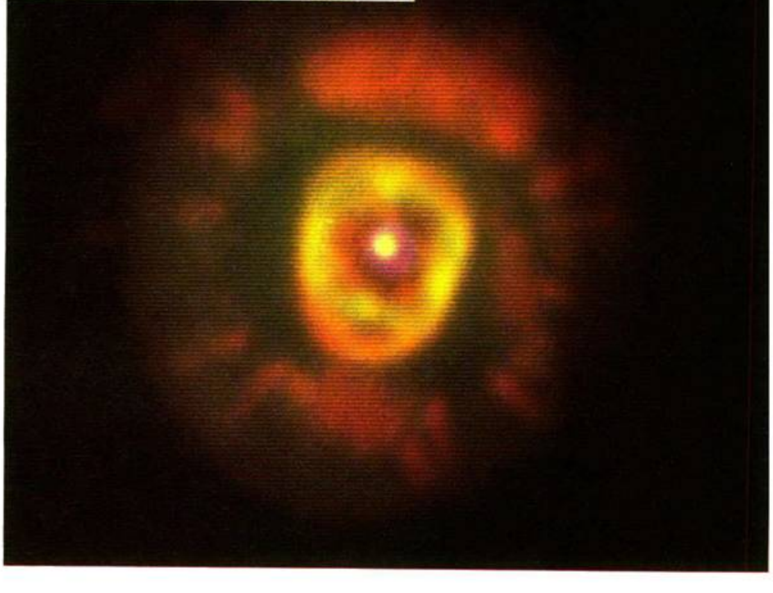

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Twenty-five years ago Apollo set down on the Moon. What are the chances humans will ever go back? By Donald F. Robertson.

40 Ashes to Ashes and Dust to Dust

Some stars explode and some fade away, but most stars die by puffing off their atmospheres as planetary nebulae. Astronomers now have developed a new picture of how these stars evolve. By David J. Eicher.

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A 300-foot radio "eye" reveals an unprecedented view of a cosmos teeming with quasars, remote galaxies, and clouds of hot gas. By Richard Talcott.

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It's a great month: Two eclipses, a reliable meteor shower, and the planet Mercury await your observing pleasure. By Deborah Byrd and Jeff Kanipe.

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Here it is — our survey of astronomy software, designed to help you choose the computer programs you really need. From the editors of ASTRONOMY magazine.

88 Take the Pluto Challenge

It's small. It's faint. It's hard to see. But with an 8-inch scope and our observing guide, finding this elusive outer planet makes the challenge easy. By John Shibley.

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On May 10 the Moon's shadow will blanket North America in semi-darkness, providing millions with a rare view of the Sun reduced to a ring of light. By Richard Talcott.

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Star parties are a great way to have fun while doing astronomy, especially when you know how to enjoy them. By Robert Burnham.

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COVER

THE DEATH THROES of most stars are seen as wispy tendrils of glowing gas, as in the Helical Nebula. To learn more about how typical stars die, see page 40. Photograph by Bill and Sally Fletcher.

BEHIND THE SCENES

Click-click. Whirr, whirr. *Beep!*

When ASTRONOMY was founded some 20 years ago, most skygazers did all their astronomical number-crunching on one of those new "four-bangers" — a simple 4-function calculator that cost about $100. I know. I was one of them. (Actually, the machine I dug deep for was Hewlett-Packard's lovely HP-35. OK, it cost $400. But it did trig functions, it did logs, it did nth roots — plus it was a beautifully crafted piece of sculpture that even *looked* intelligent. If you think I'm kidding, you never held one.)

Today, when CD-ROM drives and 66 megahertz chips put most of a gigabyte at the click of a mouse, "number-crunching" has become rather different. And so has the role that software plays in amateur astronomy. Accompanying this issue you'll find a 16-page buyer's guide to astronomy software that associate editor Dave Bruning compiled. The diversity of programs you'll find described in it underscores how much a computer can do in the hobby.

It turned out that Dave had a bigger task than either he or I expected. There's a lot of astronomy software on the market! As you might expect, planetarium programs are numerous. But he also found scads of CD-ROM databases, image-processing programs, and visualization software. Bulletin boards? Look at them all. And backyard astronomers have just begun to use networks to link up to each other and to databanks of words, numbers, and images.

Where's all this headed? Frankly, we don't know. It seems clear, though, that the trend of increased memory, faster speeds, and larger data storage is going to continue. This means, at the very least, that pulling together raw data on the celestial objects you observe is going to get easier. And it also means that sky simulations are going to get better and more ambitious.

Will this enrich our experiences in astronomy? I think it will. Obviously, computers don't appeal to every backyard astronomer — and of course you don't need one to look at galaxies or the Moon. But computers make planning your observations easier and they can help us all enjoy the new discoveries that come out of NASA and the world's observatories. Yet I sometimes think their most valuable function may be to let us show others some of the wonderful things that astronomy is about.

On an unrelated matter, I'd like to take a moment to note the departure of Alan Dyer, who has left to take a planetarium programming job in Calgary. And I'd like to welcome our new associate editor John Shibley. You'll find John's byline on the Pluto observing story (page 88). Farewell, Alan — and welcome aboard, John.

Sincerely,

Robert Burnham

Robert Burnham
Editor

LETTERS

Goodbye, Scotty

I was devastated to hear about the death of Walter Scott Houston, who enriched all of our lives with his column "Deep Sky Wonders" (see Amateur News, page 22). I began reading Scotty's articles in 1963 when he was writing for several astronomical publications, including *Sky & Telescope* and the Astronomical League's *Reflector*. These articles always inspired me to drag out my telescope or at least a pair of binoculars even in the middle of a Michigan winter.

In 1974 my wife Dolores and I honeymooned at the Astronomical League meeting in East Lansing. We met Scotty there for the first time, and he spent a great deal of time with us because of a mutual interest in meteorites. He charmed us with endless stories, and he seemed charmed himself by Dolores. Little did we know that he was testing anecdotes on us before using them in his convention banquet speech! Scotty was a great speaker. He delighted everyone who heard him with his quick wit and the sparkle in his eye.

Among the stories he told that night was the one about creating his first telescope, a 1-inch, 40x refractor made with "scavenged" parts from his mother's eyeglasses. After extracting the needed lens, he climbed into his attic and dropped the frames into an exterior wall of the house. The deed went undiscovered. With the telescope, said Scotty, "I was Galileo. I discovered the Moon, Jupiter's moons, and Saturn's rings." His writing about deep-sky objects allowed us all to discover much more than that.

Scotty was loved by thousands of backyard astronomers. In 1987, organizers of the Riverside Telescope Makers Conference in California surprised him with a cake for his 75th birthday. More than 1,000 people who had

(continued on page 12)

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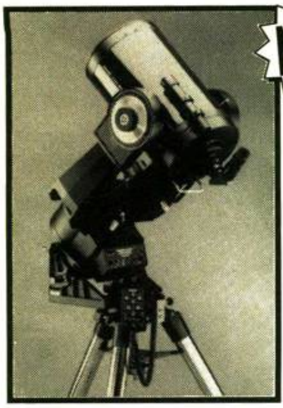

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Starfinder Dobsonian 16

16" f/4.5
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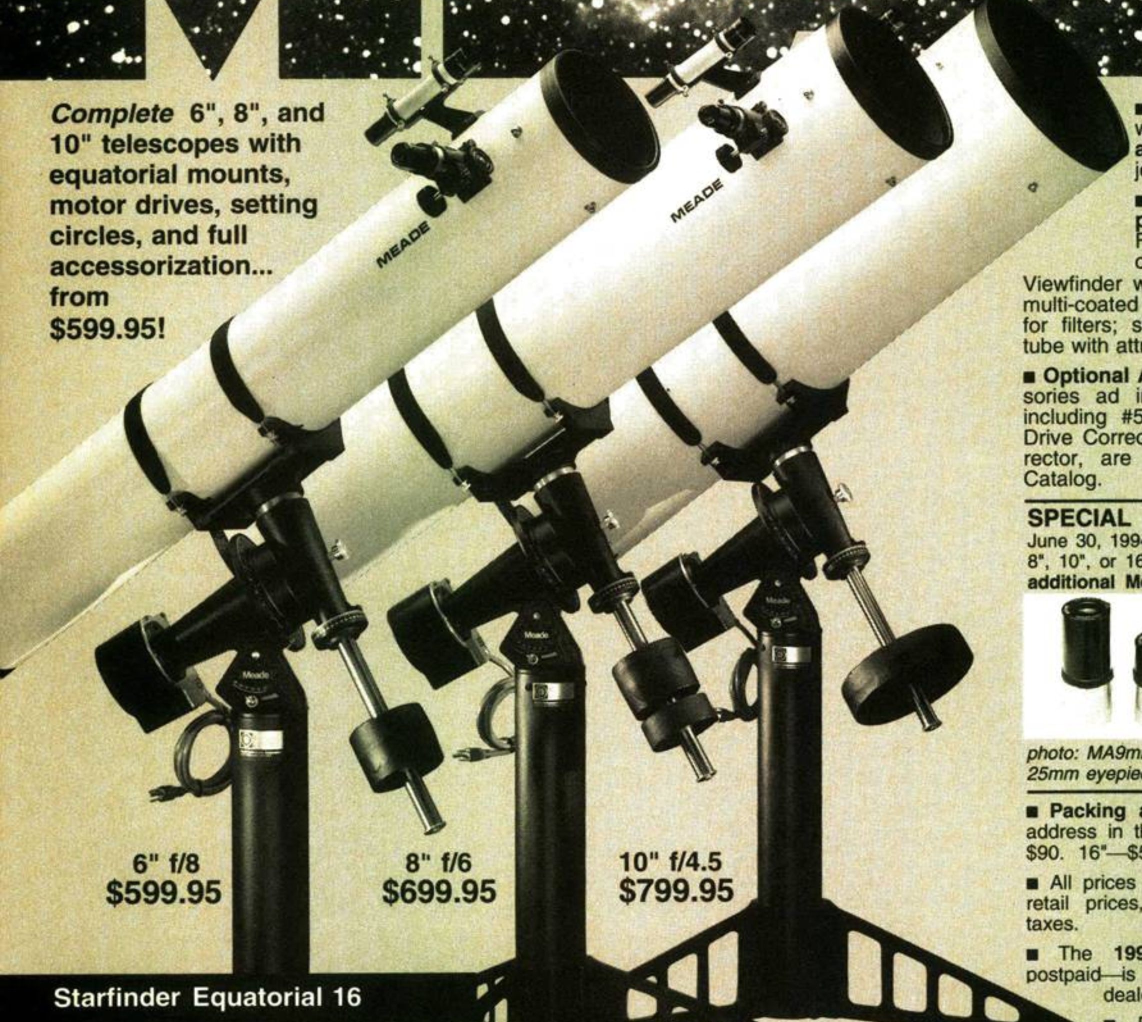

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■ **Packing and UPS Shipping Charges:** to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90. 16"—$55 packing, shipped truck freight collect.

■ All prices shown are suggested USA mail-order retail prices, not including any applicable sales taxes.

■ The **1994 Meade General Catalog**—$3.00 postpaid—is available from any authorized Meade dealer or directly from Meade Instruments.

■ For further information call Meade Instruments at 714-756-2291 or contact one of these authorized mail-order dealers:

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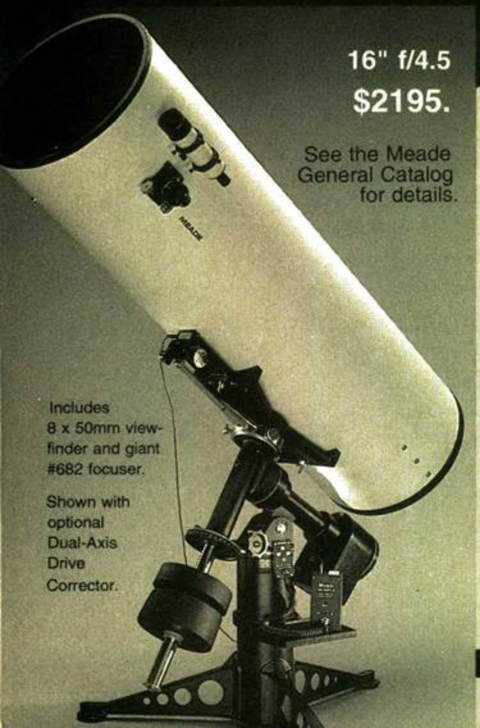
Starfinder Equatorial 16



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■ **Precision Equatorial Mount:** Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs, for rock-solid support of the optical tube. The telescope moves effortlessly from object-to-object on precision bearing surfaces. Polar and declination shafts are 1" solid steel. Setting circles on both axes facilitate the location of faint objects directly from their catalogued coordinates.

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Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm each: **$87.95** (3.29)

32mm (52°); **40mm** (44°); each: **109.95** (3.79)

56mm (52°; 2") **229.95** (4.78)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

f/6.3 FOCAL REDUCER/FIELD

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (3.60)

Series 4000™ Super Wide Angle

For exquisite wide-angle images at low-to-medium powers, ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8, 18, and 24.5mm are superb complements to the #140 Barlow.

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The ultimate eyepieces; extreme image sharpness over an amazing 84° field.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)—**4.7mm: $179.95** (3.29); **6.7mm: 219.95** (3.29); **8.8mm** (1.25"/2"): **269.95** (4.78); **14mm** (1.25"/2"): **329.95** (4.78)

Series 4000™ #140 2x Apochromatic Barlow Lens

The most advanced Barlow Lens available for commercial telescopes; includes 3-element, air-spaced optics, multi-coated. Unmatched in image resolution, contrast, and color correction. Accepts1.25" eyepieces. Lens dia. 28mm; clear aperture 26mm.

$79.95 (3.29)

FREE! Series 4000™ EYEPIECES!

Through May 31, 1994, buy Meade Series 4000 Eyepieces at the regular price and receive additional eyepieces absolutely FREE! It's this simple:

Buy ANY TWO Super Plössl Eyepieces: SP 6.4, 9.7, 12.4, 15, 20, 26, 32, 40mm

Receive ANY ONE eyepiece FREE: SP 6.4, 9.7, 12.4, 15, 20, 26mm

Buy ANY ONE Eyepiece: SP 56mm, SWA 13.8, 18, or 24.5mm

Receive ANY ONE eyepiece FREE: SP 6.4, 9.7, 12.4, 15, 20, 26mm

Buy ONE: Super Wide Angle 32mm (2")
Receive ONE: SWA 13.8mm FREE

Buy ONE: Super Wide Angle 40mm (2")
Receive ONE: SWA 18mm FREE

Buy ONE: UWA 4.7mm or 6.7mm
Receive ANY ONE eyepiece FREE: SP 6.4, 9.7, 12.4, 15, 20, 26mm

Buy ONE: Ultra Wide Angle 8.8mm
Receive ONE: SWA 13.8mm FREE

Buy ONE: Ultra Wide Angle 14mm
Receive ONE: SWA 18mm FREE

This offer is valid between February 20 and May 31, 1994, at participating Meade dealers and is subject to eyepiece availability.

Series 3000™ Plössls

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce excellent results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$59.95** (3.29) **Any 2: $52.95** each; **Any 3: $48.95** each; **Any 4 or 5: $46.95** each.

Series 3000™ Plössl 40mm

A perfect complement to the Series 3000 Plössls at left, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, multi-coated. Barrel dia. 1.25", threaded for filters. Apparent field: 44°. **$79.95** (3.79)

Series 4000 Photo-Visual Color Filters (1.25")—Made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow-Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue. each **$12.95** (2.29)

Moon Filter #ND96—Reduces brightness by 87%.	**15.95** 2.29)
Set #1—4 filters: #12, #23A, #58, #80A	**49.95** (2.79)
Set #2—4 filters: #11, #25A, #47, #82A	**49.95** (2.79)
Set #3—4 filters: #8, #21, #38A, #56	**49.95** (2.79)
Sets #1 & #2—8 filters	**89.95** (3.29)
Sets #1, #2, & #3—12 filters	**129.95** (3.48)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high contrast observing of faint nebulae.

#908B—Threads into 1.25" eyepieces; 26mm dia.	**79.95** (2.98)
#910B—Threads into 2" eyepieces; 44mm dia.	**119.95** (3.29)
#911B—Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.29)
#908N—Threads into 1.25" eyepieces; 26mm dia.	**89.95** (2.98)
#910N—Threads into 2" eyepieces; 44mm dia.	**129.95** (3.29)
#911N—Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.29)

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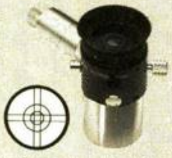
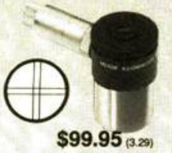


Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Internal batteries included. Multi-coated optics. Bullseye reticle. 1.25"

$129.95 (3.29)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$109.95** (3.29)

MA 12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Includes wireless red LED illuminator with internal batteries and variable brightness control. **$99.95** (3.29)

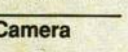
MA 12mm--Same as above, but with cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (3.29)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter **$99.95** (3.29)

Camera Adapters (1.25" & .965")



Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-Mount, available separately.

.965": $27.95 (2.79) **1.25": $29.95** (2.79)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-Mount for your camera. **$39.95** (2.79)

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TELE-EXTENDER

For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Use with T-Mount for your camera.

Basic Tele-Extender:*(above)* Fixed projection power; use with eyepiece for lunar and planetary photos. **$29.95** (2.79)

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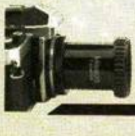


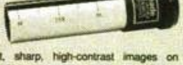
For Prime Focus photography with any Meade or Celestron SCT. Use with T-Mount for your 35mm camera.

$26.95 (2.79)

2X Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (3.29)

2x-3x Variable Barlow (1.25")



#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25" **$59.95** (3.29)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (2.79)

Modified Achromatic Eyepieces

An improvement on the traditional Kellner design, these 3-element Modified Achromatic eyepieces give sharp, faithful, well-corrected images of the Moon, planets, and deep-space at an economical price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$29.95** (2.79)

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- Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA
Orders: 800-843-4780; Info: 818-505-8424.

CITY CAMERA, Dearborn, MI.
Orders: 800-359-5085; Info.: 313-846-3922

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info: 718-436-6262.

LUMICON, Livermore, CA.
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Orders: 800-621-2248; Info/IL: 312-332-2000.

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ED APOCHROMATIC REFRACTORS

"...Through the Meade 5" Saturn was terrific. Aside from the usual things such as the Cassini Division, I could see the olivine cap on top of the ball, as well as subtle detail in the main equatorial belt. What really struck me as amazing was the true-to-life colour rendition the APO provided. The colour correction of the Meade 5" is as perfect as I've ever seen in a refractor. I can wholeheartedly recommend the Meade 5" APO."—*Richard Anderson, Mississauga, Ontario, Canada*

4" Model 102ED $2195.*

5" Model 127ED $2795.

6" Model 152ED $4495.

7" Model 178ED $5495.

Meade ***ED* super multi-coated objective lenses** yield ultra high resolution, high-contrast images, virtually free of any false color.

LXD 650 (4", 5") and **LXD 750** (6", 7") **equatorial mounts,** new for 1994, *virtually eliminate gear backlash,* resulting in the most rigid, flexure-free mounts available.

Standard accessories include 8 x 50mm viewfinder, 2" diagonal mirror, Super Plössl 26mm eyepiece.

Optional **#1697 Computer Drive System** includes 4 drive speeds on both axes (2x, 32x, 2°/sec., 8°/sec.); Smart Drive™ periodic error corrector; keypad hand controller with digital readouts; automatic GO TO capability from any input RA and Dec or from 747-object library—**$695.** 8000-object CNGC library (a 2-minute plug-in) available separately at **$99.**

Standard Field Tripod (4", 5") and **Giant Field Tripod** (6", 7") provide rock-solid support for the telescope assembly.

Prices listed are for complete ED Apochromatic Refractors, including optical tube assembly with #684 giant 2.7" focuser; 8 x 50mm viewfinder; #930 2" diagonal mirror with 1.25" adapter; Super Plössl 26mm eyepiece; 4" and 5" models include the LXD 650 equatorial mount and standard field tripod; 6" and 7" models include the LXD 750 equatorial mount and giant field tripod; each mount is provided with manual slow-motion controls, analog setting circles, and locks on both axes.

To order, contact your Meade Advanced Products dealer. Packing and shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.

*All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

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jammed into the crowded hall sang "Happy Birthday to You". The sound shook the rafters. It was a moment we will not forget, just as the whole community of amateur astronomers will not forget Scotty Houston. — *Rik Hill, Lunar & Planetary Laboratory, University of Arizona, Tucson, Arizona*

Big Bang? Big Silence.

I enjoyed reading your recent article about the Big Bang theory ("Everything You Wanted to Know About the Big Bang," January 1994). But I believe the theory has a misleading name. If, as your article states, no observer existed outside the Big Bang event, then it really didn't make a sound. By the same reasoning, we cannot call it the Big Flash, or any other descriptive name.

I think we should call it the Big Something, a name that reflects what we know about it for certain. — *Norman Smith, Keflavik, Iceland*

Professional Astronomy's Ups and Downs

I was struck by C. Renée Beveridge's article "So You Want to Be a Professional Astronomer?" (February 1994). I realize, as does Ms. Beveridge, that astronomy isn't a profession for everyone. But why does there seem to be a move afoot to discourage people from becoming professional astronomers?

I'm 35 years old and seriously interested in considering astronomy as a career. In my case it would mean going back to college after 15 years of working for a living, but it's something I've wanted to do since being bitten by the astronomy bug at age 10. Before making a decision, however, I'm going to thoroughly investigate the ups and downs of professional astronomy and see what the field entails. It sounds like Ms. Beveridge might have had a preconceived idea of what professional astronomy was all about, and when those expectations weren't fulfilled she became disillusioned.

It also sounds like Ms. Beveridge's life became "all work and no play." It's extremely important to have interests different from those involved with your job. I currently work in a hospital. For years I've seen doctors and health care providers whose entire existence revolves around their work at the hospital, and it ultimately destroys them. Let's see some articles from professional astronomers who love their work! —*Cynthia J. Cline, Winters, California*

I thought C. Renée Beveridge's article was a thinly-disguised attempt to discourage women from pursuing careers in astronomy. Assuming that the overwhelming readership of ASTRONOMY consists of men, why would you feel the need to print such a destructive article? Shame on you. — *Adrienne Jolicoeur, Montreal, Quebec*

It's a Fast-Paced Life

Graham Ryder stated that "the oldest life on Earth arose about 3.5 billion years ago" (January Letters). Participants in a meeting of German exobiologists, however, concluded last December that several lines of geochemical evidence for life go back to the earliest surviving sediments on Earth, some 3.8 billion years old. They also suggest that "primitive" life, in the form of algal mats, was already ubiquitous 3.5 billion years ago. Because the era of heavy bombardment by leftover planetesimals was just winding down 3.8 billion years ago, we must conclude that life arose extremely quickly on the young Earth. Many biologists feel comfortable with the possibility of the same process's occurring on the young Mars as well.

Ryder is of course correct when he questions attempts to search for ancient microfossils by remote sensing. But at the meeting, participants discussed a novel approach that might be used to investigate whether Mars once harbored life. The chemical element phosphorus is a common constituent of living beings and should have survived over billions of years as sedimentary calcium phosphate. An instrument such as a balloon-borne gamma-ray spectrometer could detect the spectral signature of this material.
—*Daniel Fischer,* Astronomische Nachrichten, *Königswinter, Germany*

Cheapskates in Washington?

The article "Cheap Shots" (August 1993) might as well have been called "Cheapskates, the New U. S. Congress." Politicians' reluctance to fund scientific space missions is ludicrous if one considers the relatively small percent of the U.S. budget such ventures comprise and the huge technological payoffs on Earth that come from such programs.

For far too long politicians have been concerned with pork barrel politics, their own pay raises, check-cashing scams, personal overseas junkets disguised as business trips, and pocket lining with PAC moneys.

If anyone understands the economic realities of reducing the national debt and reinventing the United States as a technological leader, they must first understand that *investing in technological* leadership is a must. The scientifically valid part of the space program is the leading way to do that. —*William Z. Morphis, Mesa, Arizona*

Catch a Falling Star

I very much enjoyed Mark Coco's article "Catch the Geminid Meteor Shower" (December 1993). Inspired by his writing, a group of observers from the area of Quebec City ventured out on the evening of December 13, 1993, to attempt recording some Geminids on film. It was an intriguing experience.

Following the author's advice, I loaded my camera with T-MAX 400 film, attached a 50mm lens and set it at f/2.8, mounted it on a tripod, and exposed it, hoping to record the faint trace of a meteor.

Suddenly a meteor passed through the field I was photographing and less than 30 seconds later, another shot past. I then closed the shutter and thought I had the prize image of the night. Sadly, however, I checked the camera's focusing ring and saw it was far from infinity. My pictures taken up to that point were no good.

I simply want to say to my fellow astrophotographers, check your settings carefully! And please, ASTRONOMY keep those great how-to articles on observing and photography coming. They give us a great deal of pleasure. — *Henri Lambert, Sillery, Quebec, Canada*

The End of the Road

This letter constitutes my farewell address. I've traveled a long road in amateur astronomy for some 30 years. But now I want out.

I was scanning my astronomy magazines the other day and came across an ad for a CCD camera. The price? A mere $5,000. Gee, telescopes with the required hardware have now crept up to only $4,000. I'll take one of each!

Backyard astronomy has given me many enjoyable evenings, but it seems it's not enough anymore to pull out the ol' 6-inch and scan the sky. Now, the advertisers and techno-nuts declare, I need a 4-meter light bucket with an IBM-compatible image factory beside my CCD and my handy satellite GPS receiver.

Whatever happened to what amateur astronomers really care about — simply enjoying the beauty of the sky? — *Mark Hladik, Casper, Wyoming*

Long Range Russian Intelligence

In your January Letters column, Roy Akers criticised Russia for pursuing a space program while their citizens are enduring difficulties obtaining sufficient quantities of food.

Mr. Akers does not appreciate the long-term wisdom of pursuing a space program. The Russians are investing in a more prosperous future. Scientific and technological know-how gleaned from exploratory missions (such as Mars) will be applied to consumer products, which in turn will open new markets and develop high-tech industries. These will add value to the Russian currency.

These long-term timescales of thinking — the only ones that ultimaterly solve many of the world's economic and societal problems — seem lost to the politicians in Washington. We should not only refrain from criticizing the Russians for pursuing a space program despite their other problems, but follow their example. — *Richard Albert, Graniteville, South Carolina*

Mr. Akers' screams are largely unfounded. A great deal of the expenditures for Mars '94 and Mars '96 are coming from the French Space Agency. The Planetary Society is providing several parts such as balloons and rovers. — *George Hammond Burns, Berowra, New South Wales, Australia*

Our New! Still Improving! Cluster of Galaxies

I greatly enjoyed Paul Hodge's article "Our New! Improved! Cluster of Galaxies" (February 1994). While many of the observational facts surrounding these dwarf galaxies were nicely documented, I found the interpretation of their dynamics as a consequence of dark matter to be slightly premature.

Undoubtedly we will learn a great deal about the Milky Way from these objects, but we need to work out some fundamental dynamical problems first. — *Jeff Kuhn, National Solar Observatory, Sunspot, New Mexico*

Pluto Fast Flyby Correction

Robert Burnham's excellent article on Pluto and Charon ("Pluto and Charon: At the Edge of Night," January 1994) contained one error. The ultraviolet spectrometer on the proposed Pluto Fast Flyby mission is planned to study the composition of Pluto's atmosphere rather than its surface. It will do this by taking spectra of the Sun during an occultation and thus will complement the craft's radio science study of the Plutonian atmosphere. — *Bruce Moomaw, Cameron Park, California* ☐

ASTRONOMY welcomes suggestions and additional information about articles and astronomy. Write ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or via Internet to: 72000.2704@Compu Serve.COM. Letters may be edited for length and clarity.

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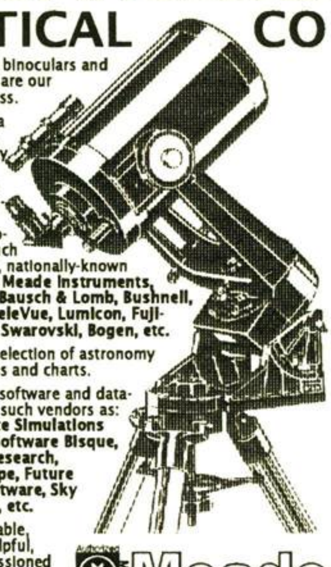

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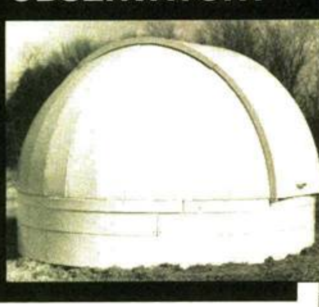

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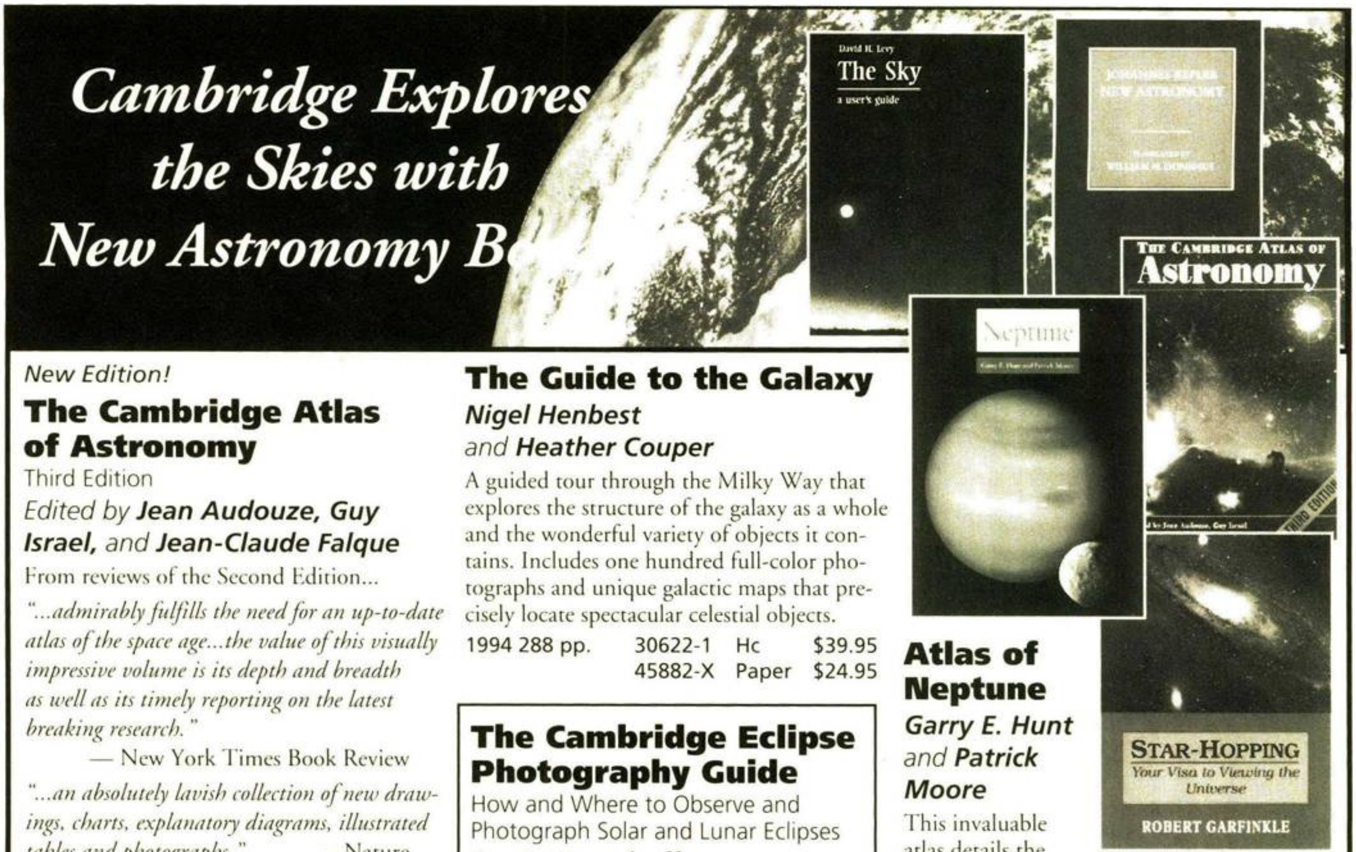

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VIEWPOINTS

Teaching Them to Hate Astronomy

by Jim Marsh

It was that Texas Star Party time of the year and, for once, time was something I had plenty of. Rather than fly, I opted to take four days to drive the 1,300 miles to the Davis Mountains, stopping to visit some friends along the way.

I arranged to spend an evening in a West Texas town with a friend I had not seen in over 20 years. After dinner Marty gave me a tour and then mentioned that a nearby college observatory should be open. He didn't know whether or not it was a public observing night, but at least someone would be there.

When we arrived just after dark over twenty students were wandering around the grounds, waiting for an instructor or teaching assistant to open the observatory. An hour passed, and still no one had shown up to unlock the building. I began chatting with students, who by then were becoming very disgruntled.

I asked how much observing time they got to enjoy during the term. The answer surprised me: "We came out to the observatory two times during the semester, and we saw Jupiter and M42."

What about the exciting things they learned in class? With collective disgust they replied, "Oh, we learned how to calculate orbits, how to figure precession, and lots of mathematical stuff like that. NOTHING like we hoped!"

What were they hoping to get from their astronomy course? After serving up the gag answer "an easy credit," students got serious. The majority of them wanted to learn about the constellations or how to locate "the pretty stuff" they saw in the magazines. One student, who wanted to work for the Foreign Service after his graduation, just wanted "to be able to talk on any subject," including astronomy.

Students at the observatory that night had majors ranging from Russian language studies to agriculture, but not a single person was majoring in astronomy, physics, or mathematics.

I asked if they would ever take another astronomy course. The answer? A universal, whole-hearted "no."

As the night wore on, I started to form some conclusions based upon what I was hearing:

First, very few professional astronomers would graduate from this school, a major educational institution. Second, whether it intended to or not, this school was doing a marvelous job of driving potential amateur astronomers away from the hobby in droves. Finally, and most important, maybe universities should consider restructuring introductory astronomy courses.

As most of us who read this magazine probably realize, there are relatively few professional astronomers in the world, due to a limited number of instruments, low funding, and few available positions. Professionals have to train for years in such core subjects as orbital mechanics, physics, and other specialized disciplines. Since less than, say, one person in a thousand who takes an introductory college astronomy course actually goes on to become a professional astronomer, why not tailor coursework to meet the needs of the many instead of an extremely small minority?

Colleges should offer courses in popular astronomy which provide broad overviews. Topics could include the constellations, the types of objects in the heavens, and a very general introduction to math-driven concepts such as optics, orbits and precession. Most of all, coursework should emphasize the "three Os": Observing, observing, and observing.

Gérard Therin

Students I talked with that night complained that they didn't get to use the telescope nearly as much as they wished. An introductory course that keeps in mind the educational goals of all college majors would prove more valuable to most students in their future pursuits; it might even instill (God forbid) a love of the heavens!

For those few who want to beat a path into professional astronomy or desire a more technical classroom experience, by all means keep such appropriate courses available. But give general students, those majoring in English, the arts, or even another science, something to learn and love, not something to learn and hate.

Learn to hate? Unfortunately, it happens far more often than we are willing to realize. My last question on that Evening of the Locked Observatory was what the course had taught them. One student answered immediately, "Well, I learned to hate astronomy." Others murmured agreement.

The professor and his assistants must have agreed. They were to have been at the observatory by sundown; when my friend and I left at midnight, after all the students had gone, no one had shown up to open the observatory.

Perhaps it is only by good fortune and maybe even a modicum of dumb luck, that I, too, didn't learn to hate astronomy.

Society's Elusive Dr. Benjamin Peery

by Beatrice M. Hogg

While watching "The Astronomers" on public broadcasting, I saw something as awesome as the stars and galaxies that flashed across my TV screen. It was a phenomenon I didn't think existed, more intriguing than the most distant quasar. The miraculous sight I saw that evening was the interview of a black astronomer, Howard University's Dr. Benjamin Peery.

As a poor black child growing up in western Pennsylvania, I was not encouraged to go into science. My budding love for astronomy was seen as just a child's whim, not something to be nurtured and cultivated. In grade school, our class went on a field trip to Buhl Planetarium in Pittsburgh. Mesmerized by the sky show, I wanted to return again and again just to see the heavens circle above my head. But my parents were solidly earthbound, and I never got the opportunity to return. To buy even a small telescope would have seemed a frivolous expense to an illiterate coal miner father and a mother who had a fourth-grade education. I had no one with whom I could share my fascination with stars and planets. The only connection between impoverished black people and astronomy I knew of concerned runaway slaves who followed the "drinking gourd" (the Big Dipper) to freedom. As a child, I didn't know people made astronomy a profession. Even if I had known, I would never have considered it as a vocation.

In college, I discovered ASTRONOMY in the school bookstore. It rekindled my long-dormant love of science. I hungrily pored over the pages of the magazine from front to back, reading even the telescope ads. Because I was steered away from science as a youngster, it took a long time to understand astronomical theory, but I kept at it.

I've retained my love of the planets and stars and the mysteries of the universe. I am still waiting to get my first telescope, but my bookshelves are full of star charts and books on everything from the solar system to black holes. Last year, I went to Lick Observatory, my first visit to a working observatory. I felt I belonged there; I guess I'll always be a frustrated astronomer, one who will have to be happy to pursue the subject as an amateur.

How many other Black children have gazed up at the stars only to be knocked down to Earth by well-meaning but misunderstanding parents? How many potential Dr. Peerys have been lost because Black or underprivileged children are pushed away from the sciences? Why is it that some of our youth see science as "uncool?" Why is it acceptable to know the Lakers' starting lineup, but not acceptable to know the names of Jupiter's moons? Our schools need to expose all students to the sciences, with those who show interest in astronomy encouraged to pursue their dreams.

Vernon E. Grove

I hope the day will come when the sight of a Black astronomer is not a wonderful anomaly, but a common sight, like stars in a night sky. □

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Little Dark Matter in M81

Researchers using the Very Large Array radio telescope outside of Socorro, New Mexico, have studied how hydrogen gas is distributed throughout the spiral galaxy M81. David Adler of the National Radio Astronomy Observatory and David Westphal of the New Mexico Institute of Mining and Technology find the gas lies in the spiral arms, extends much farther from the galaxy's center than the stars do, and forms small knots and kinks.

Although spiral density waves shape the general structure of the spiral arms (see "What Puts the Spiral in Spiral Galaxies," ASTRONOMY, September 1993), small-scale phenomena such as star formation and supernova explosions are just as important in determining the detailed structure of the galaxy. Adler says, "Density waves don't explain the small-scale structure."

Adler continues, "The more detail we see, the more complex the galaxy becomes." For example, the bright core of the galaxy seen in visible light images becomes dark in their radio image. The researchers conclude that the galaxy used up all the hydrogen gas at the center while forming stars.

Measuring the rotational velocities of the hydrogen gas, the astronomers found that the gas slows down in the galaxy's outer region. This is unlike the rotation in other spiral galaxies, where the velocity remains high to the edge and indicates that M81 has little dark matter. According to Westphal this implies that "dark matter is not uniformly distributed among galaxies — some have more and some have less."

Assessing Earth Impact Hazards

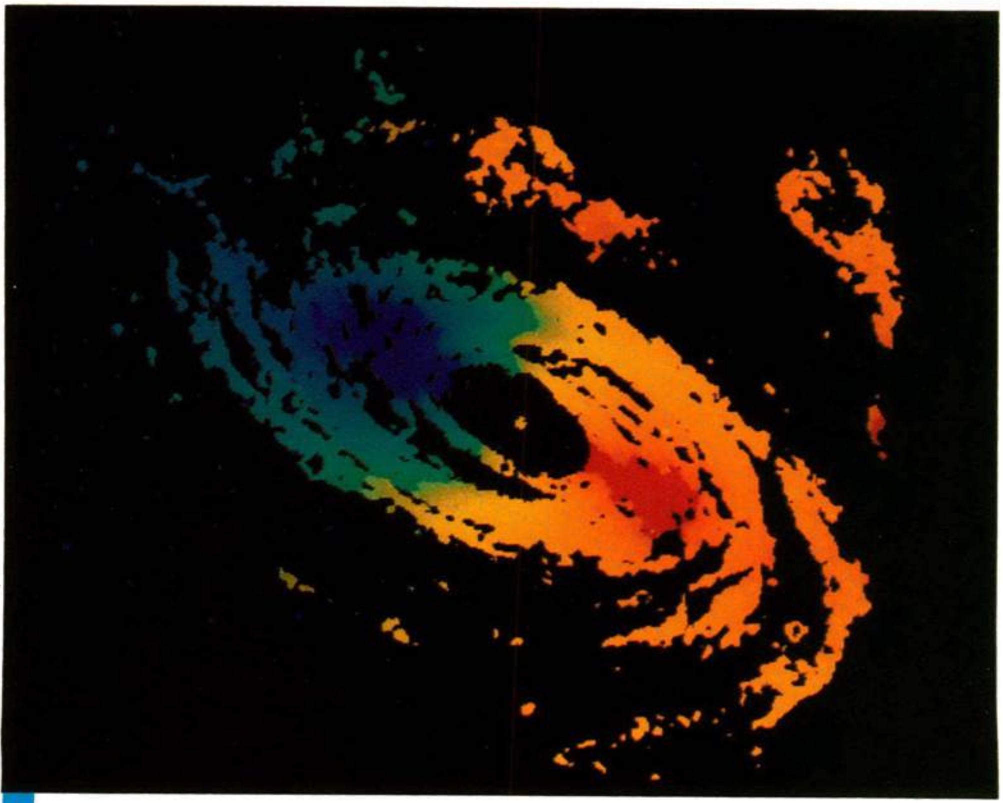
There's a 1 in 10,000 chance of our being struck by a 2-kilometer asteroid in the next 100 years, say planetary scientists Clark Chapman (of the Planetary Science Institute) and David Morrison (NASA Ames Research Center).

Writing in the January 6, 1994 *Nature*, they note that by the end of 1993, 163 asteroids crossing Earth's orbit had been found. The largest, 1627 Ivar, is approximately 8 km across. Recent improvements in detection techniques will uncover dozens more near-Earth asteroids every year.

On average Earth experiences each year a meteoroid explosion in the upper atmosphere about equal to the Hiroshima bomb (about 0.015 megaton). Objects about 300 meters in diameter will land about every 20,000 years and leave a 5-km crater (see "Death from the Sky," ASTRONOMY, December 1993).

Chapman and Morrison argue that an object in the 500-meter to 5-km range could cause a global catastrophe killing a quarter of the world's population and hugely disrupting agriculture. Such an event will occur only twice in a million years, so the chance of its happening in our lifetime is very small. But with 5 billion people alive today this gives an average fatality rate of 3,000 per year, with a 1-in-20,000 chance for any one person during a 65-year lifespan.

This seems negligible. But it's comparable to your



David Adler and David Westphal/NRAO

RED MARKS THE REGION where hydrogen gas moves away from us in the spiral galaxy M81; blue, the region where it moves toward us. The most intense reds and blues mark the regions of highest velocities. Because these regions don't extend all the way to the edge of the galaxy, astronomers believe M81 has little dark matter.

RADIO WAVES SHOW HYDROGEN gas that traces the spiral arms of the galaxy M81 (above). The hydrogen gas extends farther from the galaxy's center than stars do as seen in the visible light image (top), indicating that the galaxy is larger than the stars suggest. The star formation process has apparently used up all the hydrogen in the galaxy's core.

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chances of dying in an airplane crash or a flood. The risk, in fact, is much higher than being killed in a terrorist attack or a hijacking, two often-feared calamities.

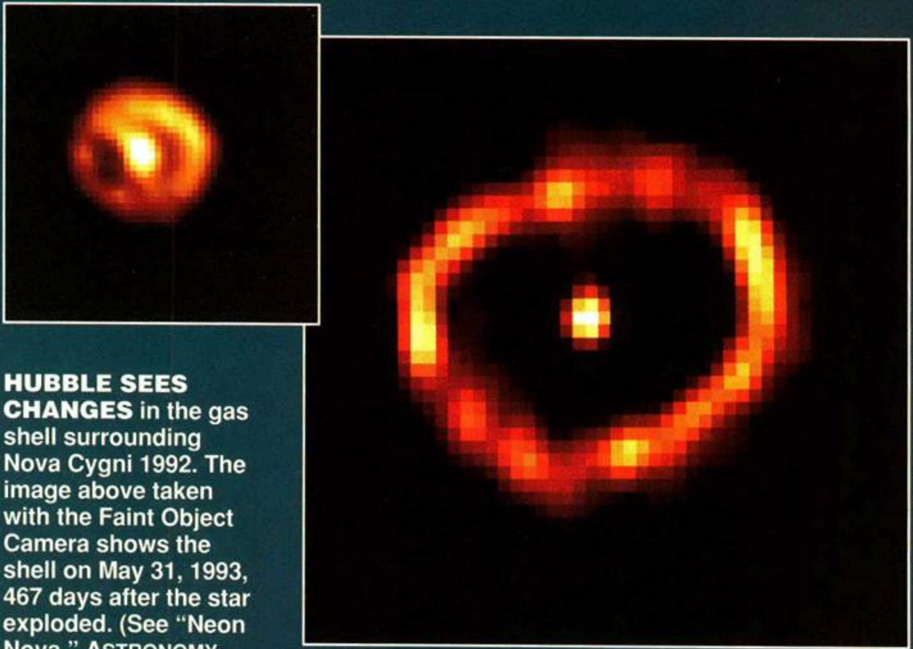
Chapman and Morrison suggest it would therefore be prudent for humanity to set up a survey capable of finding the larger near-Earth objects and cataloguing their orbits. This could warn of potential collisions decades in advance. — *Peter Bond*

Gamma-Ray Bursts — Near or Far Away?

One of the great debates raging in astronomy is over where gamma-ray bursts originate. Some astronomers think these short, violent bursts of gamma rays originate within our Galaxy while others are convinced they lie in the outer reaches of the universe (see "A Burst of Gamma Rays," October 1991, and "Bursting with Surprises," March 1992). Now two different research groups have analyzed data from the Burst and Transient Source Experiment on the Compton Gamma-Ray Observatory and reached opposite conclusions.

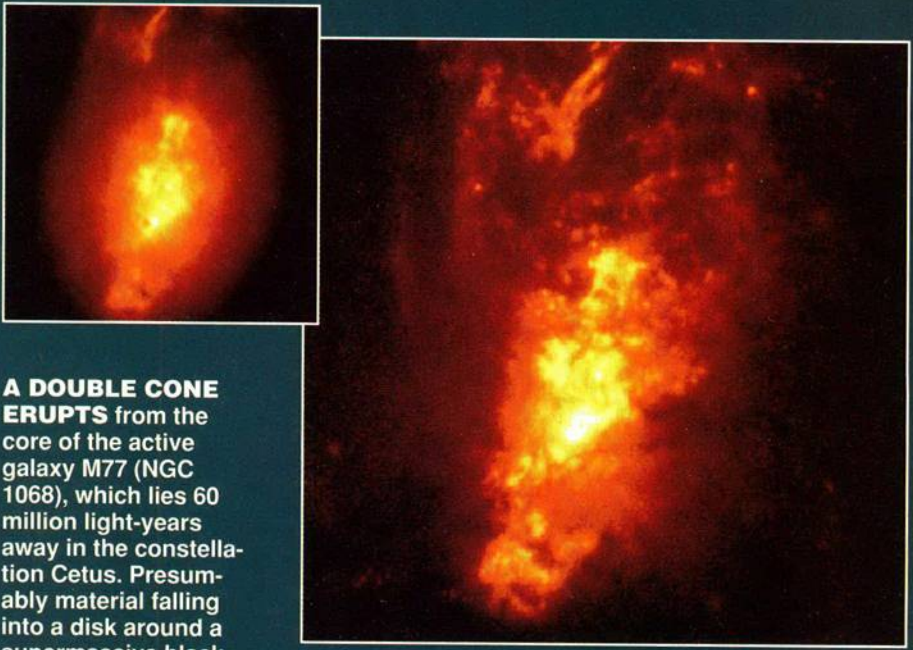
Jean Quashnock and Don Lamb of the University of Chicago looked at how the bursts were distributed in the sky. Although previous studies showed the bursts to be spread evenly, Quashnock and Lamb found that when they accounted for the statistical uncertainties in determining the bursts' positions, the bursts appeared to clump. In most cases one bright burst was surrounded by one or more fainter bursts. The researchers concluded that the clumped bursts almost certainly came from the same sources. That alone argues against the bursts' originating in the distant universe because for them to appear so bright from so far away, each burst would have to completely

HUBBLE REPORT



F. Paresce (ESA) and R. Jedrzejewski (STScI)/NASA

HUBBLE SEES CHANGES in the gas shell surrounding Nova Cygni 1992. The image above taken with the Faint Object Camera shows the shell on May 31, 1993, 467 days after the star exploded. (See "Neon Nova," ASTRONOMY, July 1993.) The image at right taken in January 1994 after the Hubble repair mission reveals the lumpy structure of the gas shell. The shell has expanded in diameter from 74 to 96 billion miles and grown more egg-shaped. Knowing the expansion speed of the shell and its angular diameter, astronomers estimate that the nova lies 10,430 light-years from Earth.



D. Macchetto, ESA, STScI/NASA

A DOUBLE CONE ERUPTS from the core of the active galaxy M77 (NGC 1068), which lies 60 million light-years away in the constellation Cetus. Presumably material falling into a disk around a supermassive black hole generates the energy that illuminates the cones, while gas and dust surrounding the black hole shield the disk from our view. The image at right taken with the Faint Object Camera after the Hubble repair mission shows the unprecedented amount of detail visible compared with an earlier Hubble image (left). The knot and filaments will enable astronomers to study the geometry and dynamics of the core and glean information about the possible black hole at its center.

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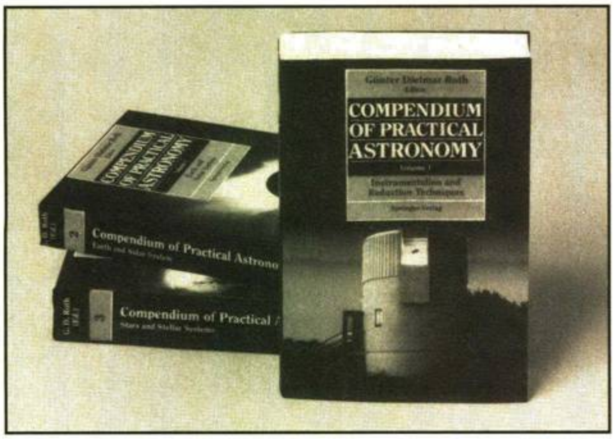
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Springer-Verlag New York Berlin Heidleberg Vienna London Paris Tokyo Hong Kong Barcelona Budapest consume the mass of the neutron star or black hole that apparently powers them. The researchers also found that bursts of medium brightness concentrated in the plane and toward the center of the Galaxy, as you would expect from sources in the Galaxy.

But the debate is far from settled. A second team of researchers led by Jay Norris of the Goddard Space Flight Center in Greenbelt, Maryland, reports that gamma-ray bursts apparently show the effects of time dilation. Time dilation is a consequence of Einstein's theory of relativity and the expansion of the universe. It says that any event occurring in the distant universe will appear to proceed more slowly than an equivalent event nearby. Norris and his colleagues found two pieces of evidence for time dilation. First they showed that dim bursts, which presumably come from farther away, typically last twice as long as bright bursts. Second, they showed that dim bursts appeared "redder" than those from bright bursts, an effect of time dilation on the bursts' energy spectra.

If nothing else, the two new studies show that the question of where gamma-ray bursts come from won't be resolved quickly or easily, or probably any time soon.

Brown Dwarfs in our Midst?

Fifteen objects within 100 light-years of the Sun may be brown dwarfs, bodies not massive enough to become stars. J. Davy Kirkpatrick of the University of Arizona and his team of astronomers used the 1.8-meter CCD/Transit Instrument on Kitt Peak, outside Tucson, Arizona, to hunt for stars of low mass. Promising objects had their spectra taken at the Multiple Mirror Telescope south of Tucson to determine their temperatures.

Because the objects all lie in the plane of our Milky Way Galaxy, the team supposes that they are young and thus must be brown dwarfs, given their cool temperatures. Surprisingly the objects have the same spectral types (M7 and cooler) as red dwarf stars. If further surveys of larger areas of the sky prove the results correct, then some dwarf "stars" could be the brown dwarfs for which astronomers have searched. But the possibility exists that cool stars and brown dwarfs may have nearly identical spectral signatures, making separation of these two types of objects difficult. Kirkpatrick says, "The true nature of objects

AMATEUR NEWS

Walter Scott Houston, 1912-1993

Walter Scott Houston, the writer who for more than four decades inspired amateur astronomers with his *Sky & Telescope* column "Deep-Sky Wonders," died on December 23, 1993, at the age of 81 years. Houston, known to friends and correspondents around the world as "Scotty" and "Twinky," was also known for his Shadowgram talk delivered at the annual Stellafane convention in Springfield, Vermont. He is survived by his wife, Miriam, and three daughters.

Scotty Houston was born in Tippecanoe, Wisconsin, in 1912. He used his first telescope, made with a lens from a pair of reading glasses, to observe the Messier objects. He attended the University of Wisconsin, and in the 1930s taught English in schools across the Midwest. During World War II Scotty taught navigation to aviators. From 1960 until his retirement in 1974, he worked as an editor for *My Weekly Reader*, an educational publication for children. When he wasn't working Scotty was observing — his interests included variable stars, meteors, artificial satellites, and, of course, deep-sky observing.

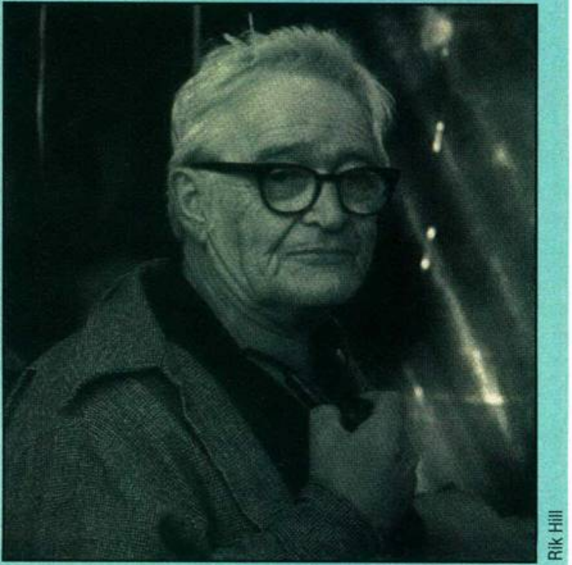
When Scotty's first "Deep-Sky Wonders" column appeared in September 1946, amateur astronomy in America was primarily concerned with lunar and planetary observing. Scotty set out to make a difference. Many years later he told the following story:

In the late 1960s, trees surrounding the small clearing to the north of the famous pink clubhouse on Stellafane's Breezy Hill were growing too tall. "It was getting so you couldn't see the sky," he said, "but in those days you couldn't even talk about cutting down trees." Scotty was a member of the Springfield club and a regular observer at the site. "I would drive up to the club meeting a day early and sneak off into the woods and cut down one tree. Now nobody notices one tree and nothing was ever said, but over four or five years the horizon was restored. I'm very proud of that."

"Deep-Sky Wonders" worked the same way. Each month Houston in his column quietly suggested a few deep-sky objects to look for and issued a mild challenge to see something new. "I never asked [the column's readers] for much," said Scotty, "but to look for something with your telescope and drop me a postcard if you could see it. But it was a challenge, you see, and they took it."

I met Scotty in 1961, at Stellafane, when I was 14. It was late Saturday night, and Scotty was holding forth for a small group, when he threw out a question, "Can you see the Veil Nebula?" I piped up, "Everybody says it's too faint to see." "Oh," he said, "have you ever looked for it?" I said that I had not. "Let's look for it," he said, pointing a nearby 10-inch telescope at 52 Cygni. "Don't believe something just because somebody tells you it's so. See for yourself." The eastern arc of the Veil Nebula was a delicate tracery spanning the field.

We will miss Walter Scott Houston.
— *Richard Berry*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classified as M7 and cooler cannot be determined until we find very close, binary M dwarfs where the masses of both objects can be computed directly."

Planetaries and White Dwarf Stars Linked

In January astronomers announced their discovery of an antiquated planetary nebula surrounding the pre-white dwarf star designated PG 1520+525. The finding directly links planetary nebulae with white dwarfs and confirms the standard model of stellar evolution.

Astronomers have long believed that most stars, except for those of very high and very low mass, die by puffing off layers of material, forming a planetary nebula. (See "Ashes to Ashes and Dust to Dust," page 40.) Theoreticians have proposed for years that the progenitor stars of planetaries, called asymptotic giant branch stars, eventually evolve into white dwarfs — tiny, ultra-dense objects that glow brightly at first but cool and dim slowly over billions of years.

The problem in making a connection between planetaries and white dwarfs results from the short life span of planetaries, which dissipate over the cosmically brief interval of several tens of thousands of years. Now the discovery of a planetary nebula around PG 1520+525 eliminates the uncertainty. Astronomers George Jacoby of the National Optical Astronomy Observatories and Griet C. Van de Steene of the Kapteyn Institute in the Netherlands describe their discovery in terms of the specific type of star they have observed.

PG 1520+525 is a subdwarf O star, an object rapidly evolving into a white dwarf. Jacoby and Steene's observations of the star with the 0.9-m telescope on Kitt Peak suggest the star has about 3/4 the mass of the Sun and a luminosity 90 times greater than the Sun's and lies at a distance of 1,500 light-years. The nebula was ejected about 36,000 years ago. Says Jacoby, "Measuring the sizes of nebulae around subdwarf O stars is critical in determining the rates at which stars of different masses evolve through the planetary nebula and pre-white dwarf phases. In this case, a planetary nebula has been caught in the act of becoming a white dwarf."

Milky Way Full of Cold Gas

Cold molecular gas is a significant part of the Milky Way's outer reaches, says astronomer Ron Allen of the Space Telescope Science Institute. And he thinks it could make up a third of all the dark matter in the outer disk of our Galaxy. Allen, together with two colleagues, used a radio telescope to study and map the gas at millimeter wavelengths.

"Cold molecular gas is likely to be present in most spiral and irregular galaxies," he adds. This gas consists mostly of hydrogen, the commonest element in the universe. But it also contains trace amounts of carbon monoxide.

Because the gas is thin and all but impossible to observe by its own emission, Allen and his colleagues studied the light from relatively bright quasars lying far beyond the Milky Way. These acted as "candles" shining behind the gas, letting the astronomers detect the gas by its effects on the quasars' spectra.

The exact nature of the cold clouds has yet to be determined, but Allen hopes that new insights into the Milky Way will result from the work. He also hopes that the new finding will help astronomers better understand the dark matter that appears to make up about 90 percent of the universe.

Finding Distances with Supernovae

Astronomers have long used supernovae, brilliant exploding stars, to measure the distances to distant galaxies. The high brightness of these objects allows them to be seen in more distant

(continued on page 28)

NOAO

THE ANCIENT PLANETARY NEBULA surrounding the white dwarf star PG 1520+525 firmly establishes a connection between planetaries and white dwarfs. Before the discovery of this nebula, astronomers suspected that central stars in planetary nebulae evolved into white dwarfs, but lacked concrete evidence tying the two together.

Merging Galaxies Common in the Distant Past

Hubble Space Telescope images of distant galaxies prove that galaxy mergers were much more common in the early universe than today. Looking at galaxies between 4 billion and 7 billion light-years away in the constellation Hercules, William Keel of the University of Alabama and his colleagues found that over one-third of the galaxies formed pairs with other galaxies.

The research team then compared those results with ground-based images of much nearer galaxies. Using statistical methods to select the same kinds of galaxies as in the Hubble images, they found only seven percent of the nearby galaxies belonged to pairs. They conclude that collisions and mergers among galaxies were quite common several billion years ago and must have played a key role in the evolution of the galaxies we see today.

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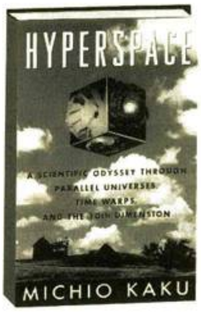
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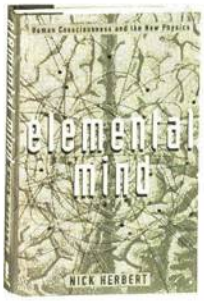
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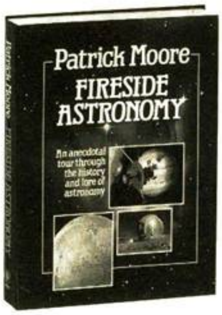
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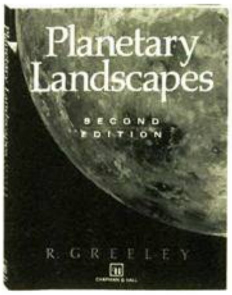
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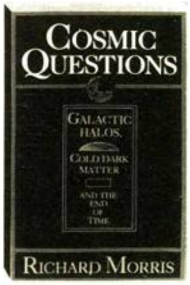
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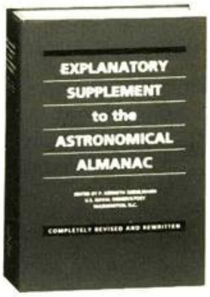
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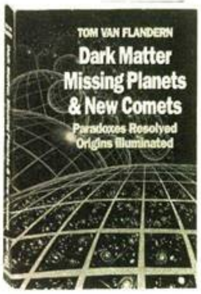
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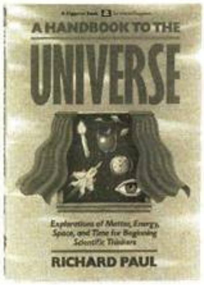
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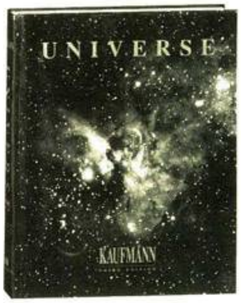
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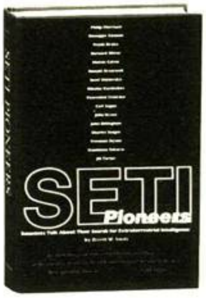
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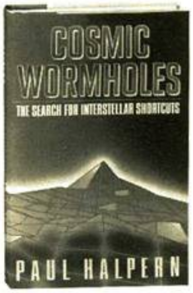
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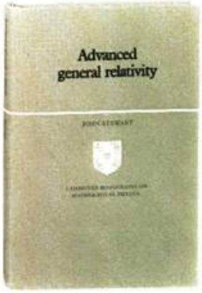
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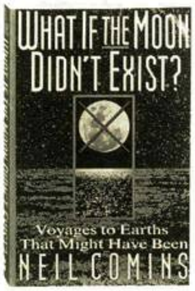
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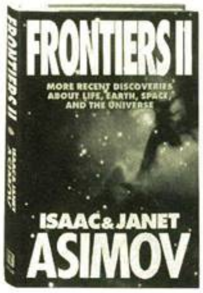
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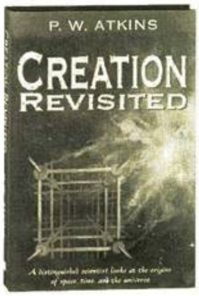
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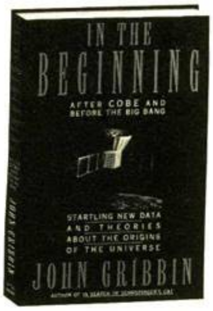
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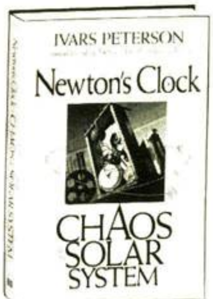
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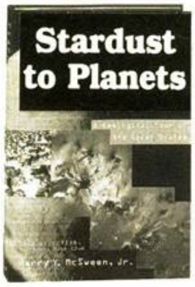
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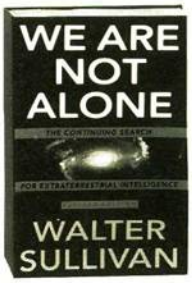
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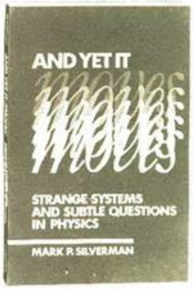
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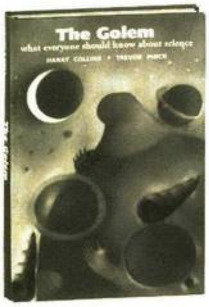
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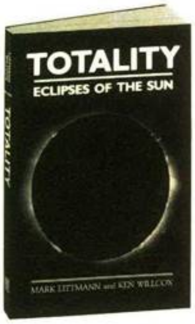
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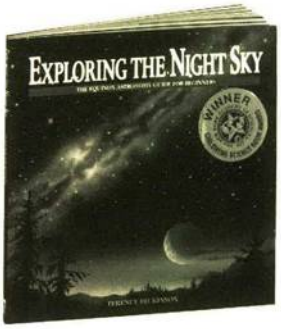
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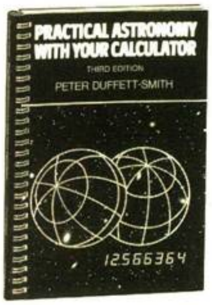
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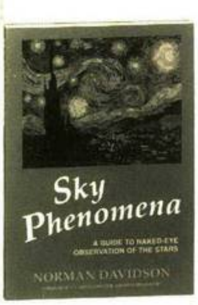
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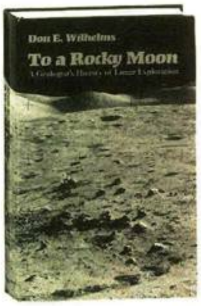
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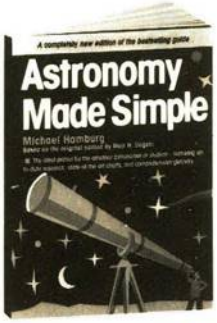
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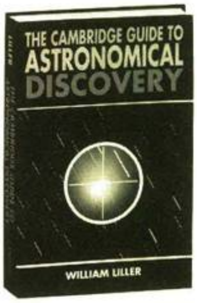
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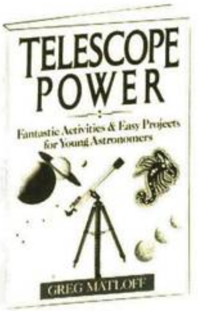
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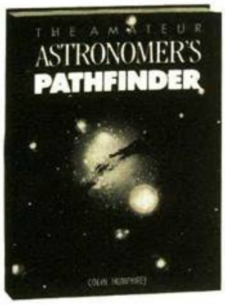
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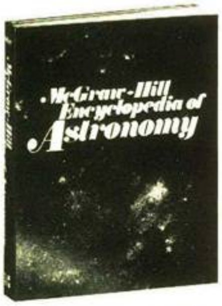
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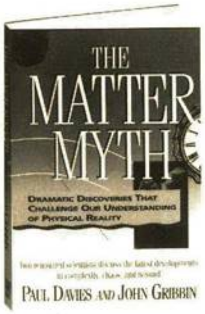
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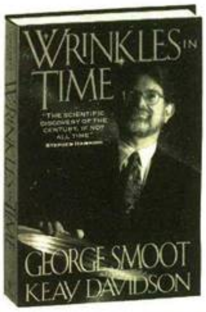
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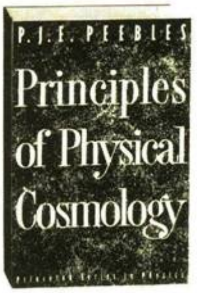
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Astronomy 5/94

galaxies than other distance indicators such as Cepheid-type variable stars. Knowing how bright the star really is (its so-called absolute magnitude) and how bright it appears here on Earth, astronomers can determine the distance to the star and thus to the galaxy in which it lies. But recently researchers discovered that type Ia supernovae, those that have silicon lines but lack hydrogen lines in their spectra, can range in brightness by up to a factor of two.

The spread in brightness would invalidate the use of type Ia supernovae as distance indicators. But Mark Phillips of Cerro Tololo Inter-American Observatory and his coworkers have found a way to calibrate the brightness of these stars. They discovered that the relative strengths of two silicon lines in the spectrum correlate with the star's absolute magnitude. As long as astronomers can obtain a spectrum within five days of a supernova's peak brightness, they can find the distance to the star to within about 15 percent.

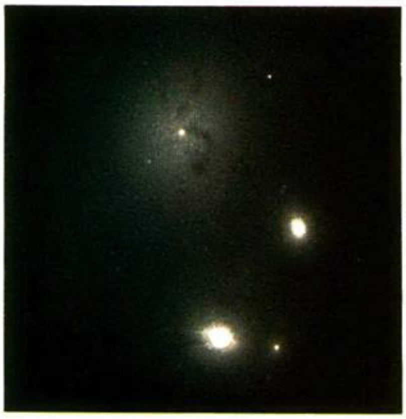
Cannibal Galaxies Rarer Than Thought

Giant, luminous galaxies at the cores of dense clusters supposedly swallow their smaller neighbors in acts of intragalactic cannibalism. That's the picture astronomers have developed over the past few years based on observations of merging galaxies in distant clusters. But the Hubble Space Telescope's recent survey of nearer clusters casts doubt on the theory. Images taken with its planetary camera before the servicing mission have found several giant galaxies that appear not to have cannibalized their neighbors.

A typical example is the giant galaxy NGC 6166A, which lies at the center of the large galaxy cluster Abell 2199, some 400 million light-years away. When Sandra Faber of Lick Observatory and Tod Lauer of the National Optical Astronomy Observatories and their colleagues imaged the galaxy, they found three much smaller galaxies nearby.

Although NGC 6166A is 20 to 1,000 times brighter than its neighbors, its core is at least a thousand times more tenuous. If in the past this giant had cannibalized some of its less luminous neighbors, the cores of those galaxies should spiral into the center of the bigger galaxy and the giant's core should appear as dense as the cores of its little neighbors. But it doesn't.

The absence of a dense core could mean simply that no neighboring galaxy ever wandered close enough to be swallowed. But because none of the other giant galaxies imaged in the survey have a high-density core, Faber and her colleagues suggest that giant galaxies cannibalize smaller galaxies much less often than previously thought.



Sandra Faber, Lick Obs./NASA

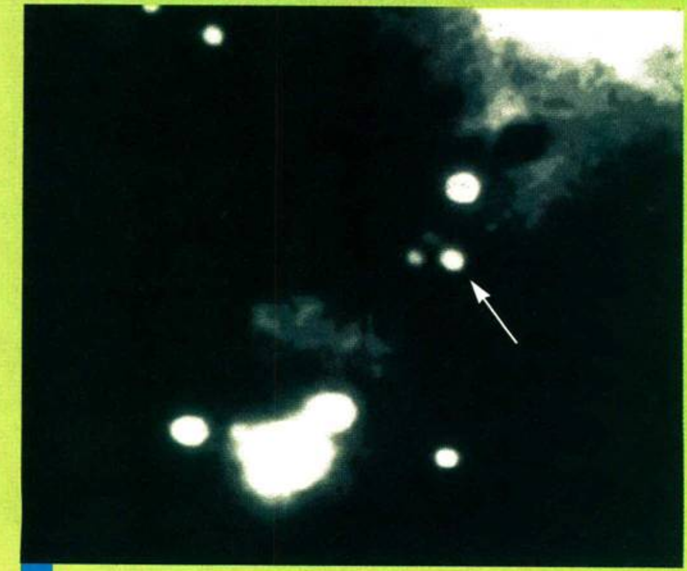
NGC 6166A IS NOT A CANNIBAL based on this HST image of the giant galaxy's core (top center) and three smaller neighboring galaxies (lower right). If the giant had swallowed another galaxy in the past, the core should be as dense as those of the smaller galaxies, but it is actually a thousand times less dense.

Brown Dwarf Identified

Brown dwarfs have remained elusive objects, primarily because they are extremely faint. (See "Desperately Seeking Jupiters," ASTRONOMY, July 1992.) These objects have too little mass to sustain nuclear reactions in their cores, preventing them from becoming stars. But young brown dwarfs, those a few million years old, can briefly convert heavy hydrogen (also known as deuterium) into light helium and create enough energy to make the brown dwarf visible.

George Rieke and Douglas Williams of the University of Arizona and Fernando Comeron of the University of Barcelona used infrared light to peer through the gas and dust of the dark cloud near Rho Ophiuchi. A star cluster about 3 million years old has formed inside this cloud. When the gas dissipates, the cluster may resemble the Pleiades, which lies at a similar distance.

Rieke and his team discovered one object in the cluster that showed a dark line of sodium in its spectrum. This indicates that the object's temperature is less than half that of the Sun. Its total energy output is less than one percent that of the Sun. Even a small, normal star of age 3 million years would be hotter and brighter than this. Theoretical models suggest this object is a brown dwarf with a mass only three percent that of the Sun — normal stars have masses at least two-and-a-half times larger than this. If this interpretation holds, this will be the first confirmed brown dwarf.



GLOWING IN THE INFRARED, this young brown dwarf (arrow) lies in a cluster of stars that formed in a dark cloud of gas and dust near Rho Ophiuchi.

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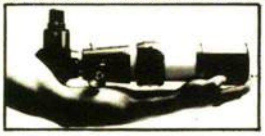

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Private Donations Keep SETI Effort Alive

The search for extraterrestrial intelligence has been given a reprieve by private donations totaling $4.4 million. Project Phoenix, coordinated by the SETI Institute, will continue work started by NASA to listen in on certain radio frequencies for evidence of extraterrestrial life. In the first year of what was to have been a ten-year effort, NASA's radio search targeted 1,000 nearby Sun-like stars. But Congress killed the program last year in an effort to reduce the nation's budget deficit.

The donations put the institute more than half way toward a goal of $7.3 million needed to support operations through 1995. Thereafter, it will have to raise $3 million a year to keep the search going through the year 2000.

Money raised so far has been earmarked to modify and improve digital receivers developed by NASA and to support search activities using the Parkes Radio Telescope in Australia. After scanning the Southern Sky for signals, equipment will be moved to Puerto Rico's Arecibo Radio Telescope for a Northern Sky survey.

Project scientists are working with a sense of urgency. In the coming decade increased radio interference from terrestrial and satellite transmitters will eventually obscure frequency bands where interstellar signals are likely to be found.

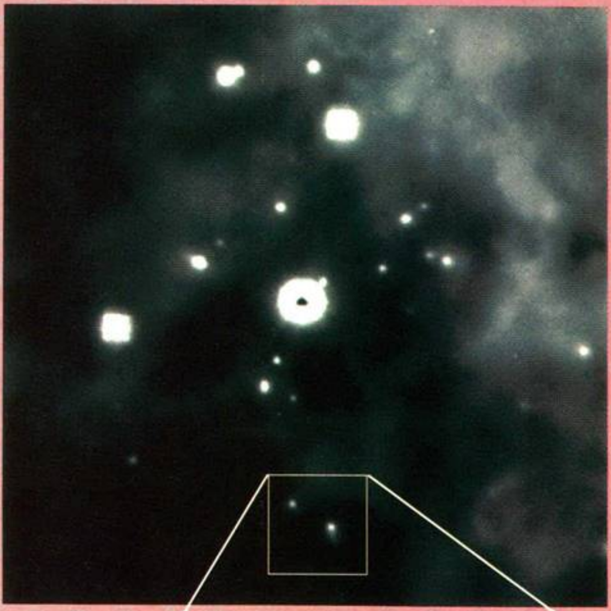
Donations to Project Phoenix can be made through the SETI Institute at 2035 Landings Drive, Mountain View, CA 93043.

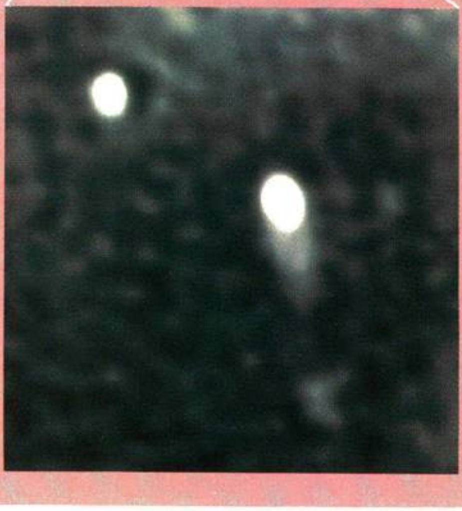
Sharp Views of New Orion Nebula Stars

Using adaptive optics that deform to counteract the distortions of bad seeing in Earth's atmosphere, a team of astronomers has made the best ground-based images ever of new stars in the Orion Nebula.

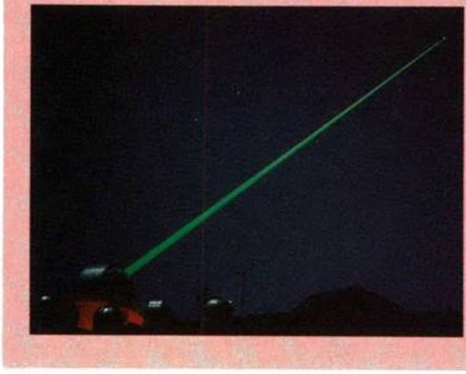
The team, led by Robert Fugate of Phillips Laboratory in Albuquerque, New Mexico, and Peter R. McCullough of the University of Illinois, used a 1.5-meter telescope at Kirtland Air Force Base. The telescope was fitted with a special laser device that monitored the changing seeing and minutely altered the telescope's optical path to cancel almost all distortion.

The results on the nebula show ionized gas shells surrounding stars with about the mass of the Sun. The shells have a cometary appearance indicating that the stars are moving through the nebula's gas — or the nebular gas itself is flowing.





A STELLAR "COMET" in the Orion Nebula: a new detail found by astronomers using adaptive optics to correct for seeing distortions in Earth's atmosphere.



Robert Fugate, Air Force Phillips Laboratory

Cheap APOs?

An optical engineer has solved the problem of how to make refractors cheaply and prevent false colors in images. If you look at Venus through many refractors, you'll see a ring of unfocused color around the planet. This chromatic aberration results from the lens' focusing the colors at different distances from the lens.

Premium refractors use an apochromatic lens for the objective that reduces the spread of colors at the focus. To avoid chromatic aberration, apochromats employ special — and expensive — glasses for one or more of the lens elements. But Robert Sigler of Lockheed's Optical Design Lab in Palo Alto, California, has found an alternative, liquid lenses. Instead of $1,100 for the glass in an apochromatic telephoto lens, materials for the liquid lens cost just $152.

Sigler's liquid lenses do more than replace the special dispersion glasses: They also improve the performance of the entire optical system. Because several of the lens surfaces contact the liquid directly, opticians don't need to polish these surfaces highly, saving on labor costs. These surfaces also don't need special antireflection coatings as present apochromats do, resulting in lower light scattering and higher image contrast. The high contrast also means high resolution. One telephoto lens using liquid lenses has more than twice the resolution of standard lenses. It's not certain when this technology will become available to backyard astronomers. □

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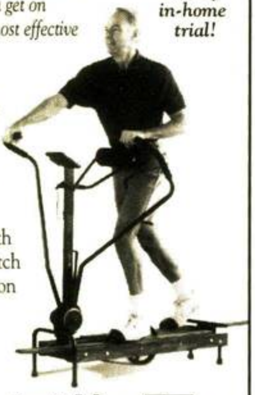

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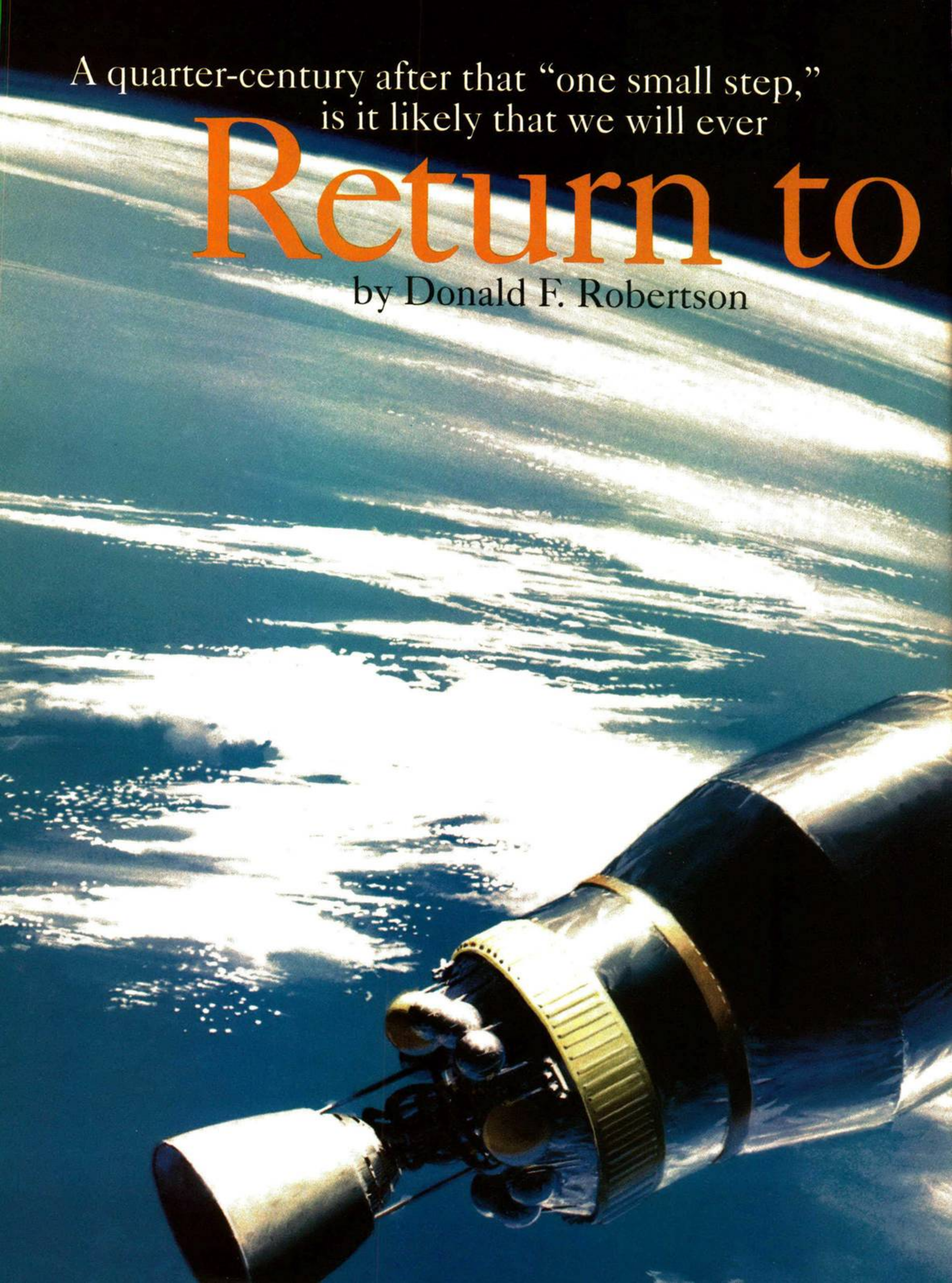
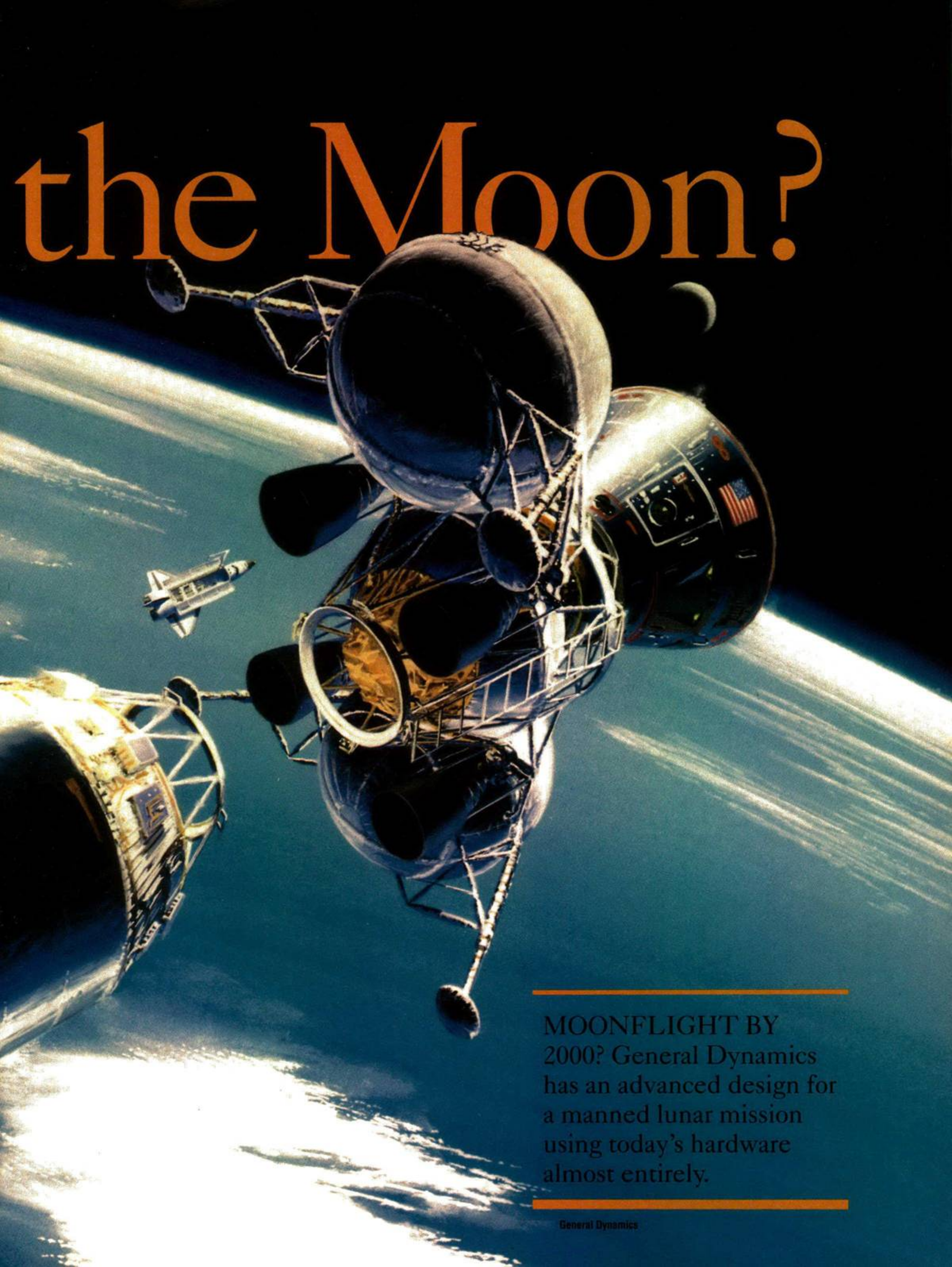


A quarter-century after that "one small step," is it likely that we will ever

Return to

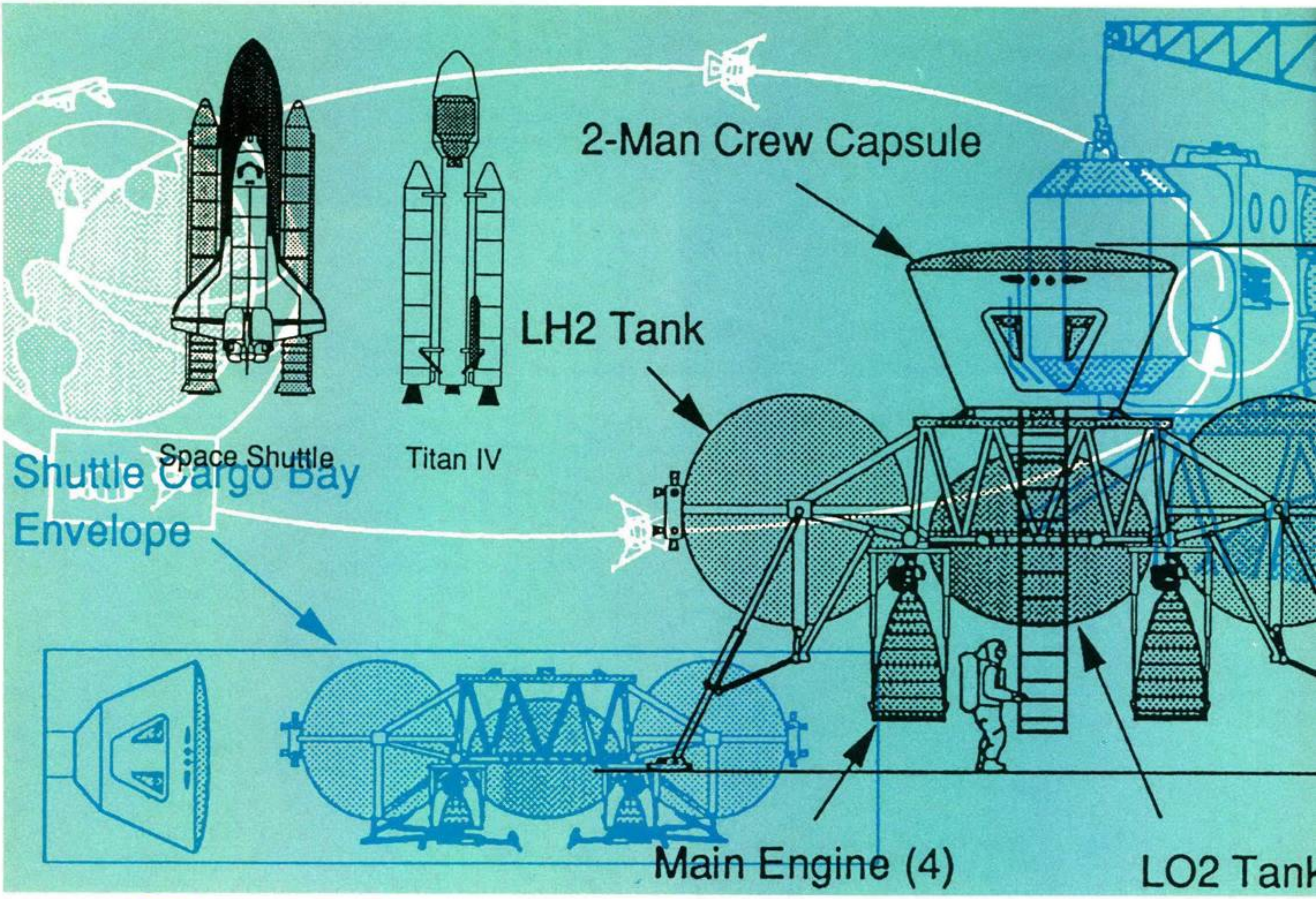
by Donald F. Robertson

the Moon?



MOONFLIGHT BY 2000? General Dynamics has an advanced design for a manned lunar mission using today's hardware almost entirely.

General Dynamics



The United States landed the first human beings on another celestial body 25 years ago. The Apollo project, arguably humanity's greatest single achievement, will be remembered long after most of the other events of our century are forgotten. With that one small step, our species embarked on an adventure without limit or end.

And stopped.

After just nine flights to the Moon, Apollo was canceled. In its place, NASA started the space shuttle to reduce the cost of getting to low-Earth orbit, a requirement, it said, for getting anywhere else.

What has happened since? In more than two decades, humanity has failed to send anyone to any celestial body. NASA spends $5 billion each year on just six to eight shuttle flights, using a vehicle felt to be dangerous and unreliable. Another $1 billion per year — soon to be $2 billion — is spent on a Space Station that has yet to fly. The Air Force has spent billions more failing to duplicate the shuttle's already existing capabilities with their giant Titan IV booster, and they have built communications satellites that cost as much as NASA spends each year on the Space Station. Meanwhile, financial and trade policies have left the United States with little disposable income to spend on "luxuries" like space exploration.

When President Bush proposed the Space Exploration Initiative to establish a permanent base on the Moon and land a crew on Mars, Congress laughed. President Clinton is staying closer to home. While not actually canceling the Space Station, he simplified the project and will bring in the Russians to help. He will use the $200 million saved this year to pay for advanced technology and the Discovery program to send small automated missions to the inner planets (see "Cheap Shots," August 1993).

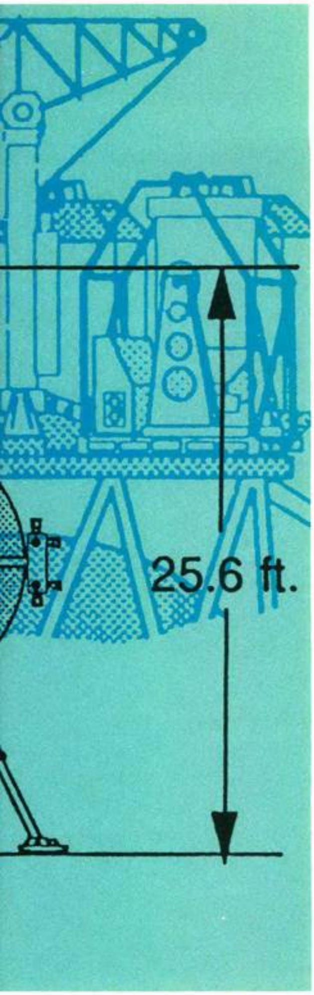
So where does that leave the grand dream of sending human beings permanently into the solar system?

It might appear the last quarter century has been a waste. But in a more important sense, perhaps it hasn't.

Space technology is far in advance of what it was during the Apollo years. Everything in Apollo was invented more or less from scratch. The Apollo vehicles were literally handmade. But today, much of that technology is readily available in the commercial market, in several different countries, and for far less money.

Nobody knows precisely how much Apollo cost; a reasonable guess might be something over $100 billion in today's dol-

> One plan could send humans back to the Moon within a decade for less than what Apollo cost 25 years ago.



General Dynamics

KEY ELEMENTS ALREADY EXIST in the General Dynamics plan. The mission goes further than Apollo by preparing the way for a lunar base.

lars. Dave Caudle, a design engineer with General Dynamics, says that his company has studied a minimum mission to land astronauts on the Moon using existing launch vehicles and costing well under $10 billion. Even allowing for vast price increases, this is a major drop in the estimated costs of lunar spaceflight.

Look at today's technology: Everything weighs much less. Aerospace electronics cost less and are far more capable and reliable than counterparts from the Apollo era. New materials invented in the National Aerospace Plane single-stage-to-orbit project can handle more heat with far less weight. Today's rocket engines operate at pressures and power densities fully three times higher than any used on Apollo. That efficiency means more mass can be lifted by a smaller vehicle. Super-high efficiency electric, or ion, engines are in advanced testing and very close to flight on communications satellites. Similar engines might be ideal for deep-space propulsion, say to Mars or the asteroids.

The hardware now available has been unfairly criticized. The much-maligned shuttle, for all its faults and extremely high price, in fact has had just one failure in 60 launches. No other large rocket anywhere in the world has been so reliable in its first 60 flights. Even after hundreds of flights, only the relatively small Delta rocket can equal it. If the orbiter were replaced with a cargo module, the shuttle launch system could orbit the same mass as a Saturn V at less cost.

Delta and the remaining old expendable rocket, the Atlas, lift far more weight for less money than they used to. Soon, Europe and Japan will be introducing modern expendable rockets, while the United States is beginning to test single-stage-to-orbit vehicles. Russia's giant Energiya booster program could probably be revived, although that country may be losing the political organization needed to maintain large, high-tech projects.

Getting into low-Earth orbit is not as inexpensive as it should be, but it's a lot cheaper than it used to be. This trend will continue, if not in the United States then in Europe, China, Russia, or Japan.

America's specialty has always been at the high end of space exploration, sending automated spacecraft far into the solar system. The Centaur, the world's first upper stage to burn high-energy liquid oxygen and liquid hydrogen and the vehicle that made America's unmanned space program possible, has undergone constant improvement. Soon it may see a major upgrade to the single-engine Centaur. This already existing "space tug" should be relatively easy to certify for human flight and is ideal for deep-space propulsion.

Europe has Spacelab, a habitable module that fits into the space shuttle's payload bay, and Italy helped a commercial company build a smaller version called Spacehab. These modules, like soon-to-be-available Space Station modules, can be adapted into habitats for interplanetary spacecraft and planetary bases. The Space Station program has advanced closed life support — which recycles consumables like water, air, and food — and solar energy technology.

Actually, the small renaissance that commercial space is enjoying may be the most important development. Defense contractors are commercializing their ex-military technology. The communications satellite industry remains the principal market for most space services and is a major moneymaker for the United States. In the next few years, global mobile telephones, portable video telephones, and other new services will require more satellites, which in turn will require new, more efficient launch vehicles.

And a trend is developing: Many would-be "British East India Companies" are building small launchers to orbit tiny communications, Earth-observation, and scientific spacecraft. These companies hope to use earnings to bootstrap their vehicles into ever larger commercial projects.

What does this have to do with sending humans to the planets? Individually, every advance is minor; what's important is the quantity.

Advanced space technology, even if developed for unrelated purposes, makes planetary exploration cheaper. Someday, the overall cost may reach what some organization is willing to pay, and human planetary missions could then become a reality.

NASA's space program may be in serious trouble but overall, the space industry is far healthier than it was during Apollo. Instead of one customer — the government — there are now many. More and more people and organizations have a stake in the space industry's success.

A lot's happening in space. Put it all together and . . . what? What can we do with today's technology? And who'll pay for it?

In 1992 and early 1993, General Dynamics studied what a near-term mission to place astronauts on the Moon might look like. The ground rules were simple. To save money, the project must use hardware already developed. The missions must be meaningful — that is, they must accomplish science not already

A SPACE TELESCOPE on the Moon could do much more than any in orbit around Earth.

done by Apollo. And the missions must test technology and obtain knowledge useful for a later lunar base.

According to Caudle, the project started in the marketing department at General Dynamics. It wanted to propose a human lunar project to NASA that was cheap enough to fit within realistic budgets yet be done within a decade, like Apollo.

"They came to me, as someone who knows the hardware, and said, 'This is what we want to do. We want to use the shuttle and Titan rockets to go to the Moon. Come up with a vehicle that will do it?'

"So I came up with a vehicle that could do it," says Caudle.

The scenario begins in 1994 and culminates in 2000. The principal launch vehicles are a slightly uprated shuttle and a Titan IV with larger fuel tanks or a European Ariane V with two extra solid-rocket boosters. The single-engine Centaur is used to get to the Moon from Earth orbit, and a derivative of the Apollo Command Module returns the crew to an ocean splashdown. The capsule would have a modern interior but retain the old Apollo shape and size to avoid extensive new wind-tunnel testing. The only vehicle developed from scratch is the lunar lander. To reduce the weight sent to the Moon, the lander must be far more efficient than its Apollo LM forebear.

Two unmanned cargo missions place supplies on the lunar surface; the third mission, manned, starts with a shuttle in a low parking orbit around Earth. The shuttle's payload contains the lunar lander, the return capsule to bring the crew back to Earth, and a lunar crew of two.

The lander and return capsule are prepared in the shuttle's payload bay. Once they are ready, the lander with attached return capsule is deployed from the shuttle's bay and the crew transfers from the shuttle to the lander's crew cabin. Meanwhile, a Titan IV or Ariane V is launched from Earth carrying a fueled single-engine Centaur. The Centaur approaches the waiting lunar lander and docks to form the complete lunar spacecraft.

The Centaur's engine begins the long burn to send the vehicle toward the Moon. Then the Centaur falls away. A little over two days later, the lander's rockets fire, and the spacecraft lands directly on the lunar surface without orbiting the Moon. After three weeks of exploration, the crew blasts off, again aiming directly for Earth. Their capsule re-enters and splashes down in the ocean.

But before the manned mission begins, the two 8.5-ton cargo flights test the entire system. The first carries an automated optical telescope and geophysical equipment, a habitat and supplies, an unpressurized rover, and lunar mining experiments. The second cargo flight sends more hardware and supplies, including a life-support system. The third flight carries the crew. A fourth mission could send equipment for extended research and the beginnings of a lunar base. All for much less money than has been assumed in the past, according to General Dynamics.

Unfortunately, the company's initial proposal underestimated the project's weight. Wendell Mendell, a NASA planetary scientist who has studied lunar bases for years, says, "When General Dynamics came to the Johnson Space Center with their presentation, NASA engineers were going crazy because they had worked the problem every which way and had not been able to do it. So they wanted to find out what in the world the secret was."

Caudle admits there was a weight problem but says, "We re-did the calculations and said we can still do it. But you would have to make a lot of modifications. You would have to have the new Advanced Solid Rocket Motor boosters for the shuttle and the new solid boosters for the Titan."

Pat Rawlings, SAIC

The Titan's fuel tanks would need a larger volume and would be made out of a light alloy called aluminum-lithium. The shuttle external tank would also be made of aluminum-lithium. Caudle emphasizes that all these changes are either in development or being considered for other missions. Unfortunately for General Dynamics, Congress has since canceled the Advanced Solid Rocket Booster, further reducing the shuttle's potential to carry enough weight for the mission.

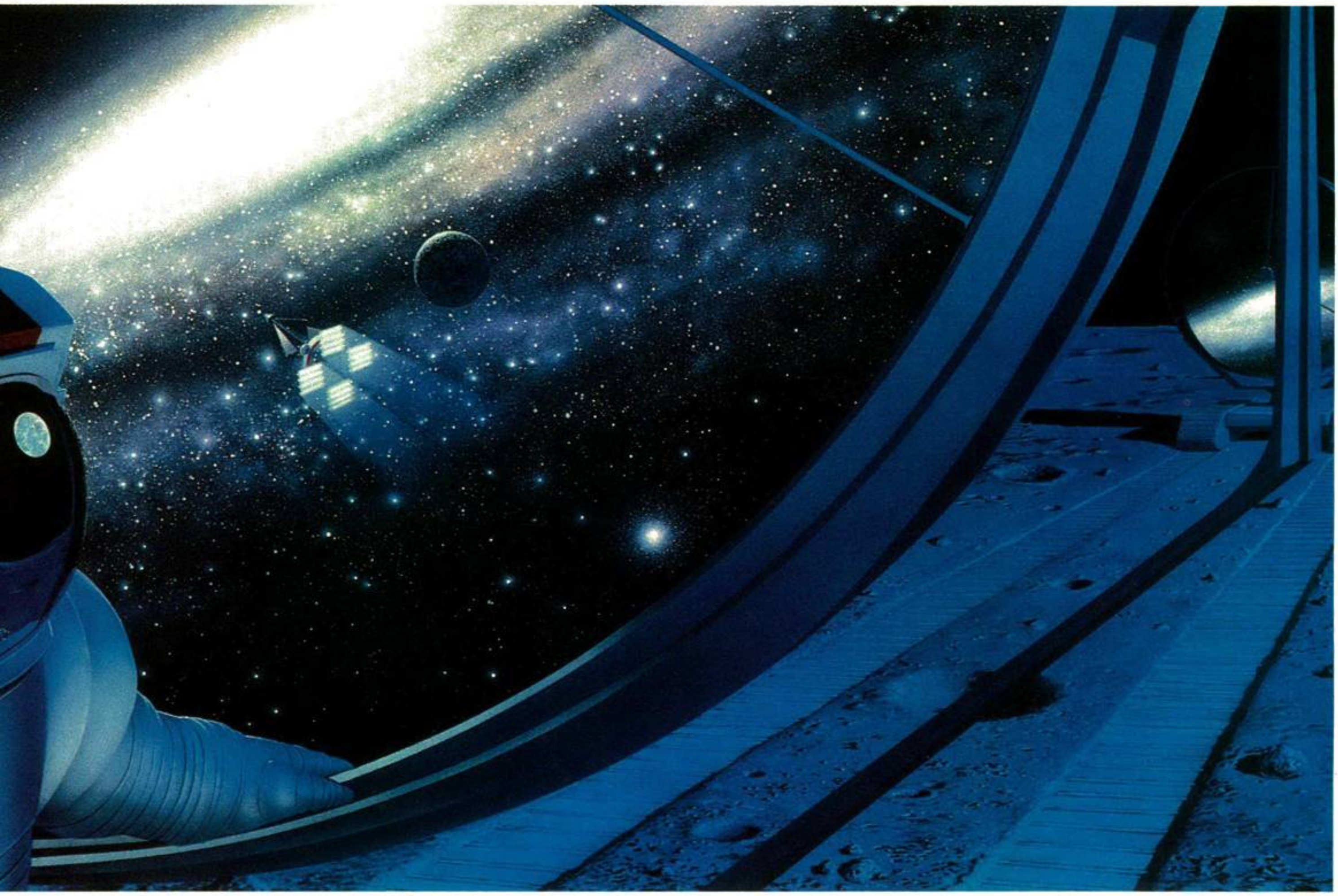
At about the same time, Mendell completed a study on establishing a relatively low-cost interferometric observatory on the lunar farside. It reached conclusions very similar to those of General Dynamics and the method of getting to the Moon was almost identical. The only real difference was the use of a launch vehicle like Russia's Energiya rather than the Titan IV.

"If you're not going to do a lot of assembly in low Earth orbit — or if you're not going to obtain fuel on the Moon — then you need a very large launch vehicle," says Mendell. That, he thinks, is where the General Dynamics study is most unrealistic.

Further, the General Dynamics scenario "does not use existing launch vehicles," he says. "It uses upgraded versions of existing launch vehicles. And when you talk about upgrading, it always sounds very simple. But quite often upgrading ends up costing almost as much as a new vehicle." Mendell maintains that to return to the Moon, a new, much cheaper way of getting to orbit is almost essential.

General Dynamics thinks otherwise. Using their plan, how long would it take to send a mission to the Moon?

"That depends on how badly you want to go," says



Caudle. "If it were an Apollo level of effort — if it were a race with Japan or something — we could get there in five years. If a normal process with some Skunk Works management and they kept the politics out of it, probably seven to eight years."

Costs? "All of the new things needed for the company's lunar mission are not trivial," says Caudle. "They'll cost millions to do, and you combine them and they become billions. But they're all much cheaper than building a new rocket. How cheap? $7 billion to $8 billion, according to Caudle, including the required upgrades to the shuttle and Titan IV.

Recent Air Force studies argue that developing a new launch vehicle from scratch would take at least a decade and cost over $10 billion. Some companies, like Boeing, think it could be done for half that. But if General Dynamics is right — *if* — then returning to the Moon with existing launchers would cost much less than developing new vehicles.

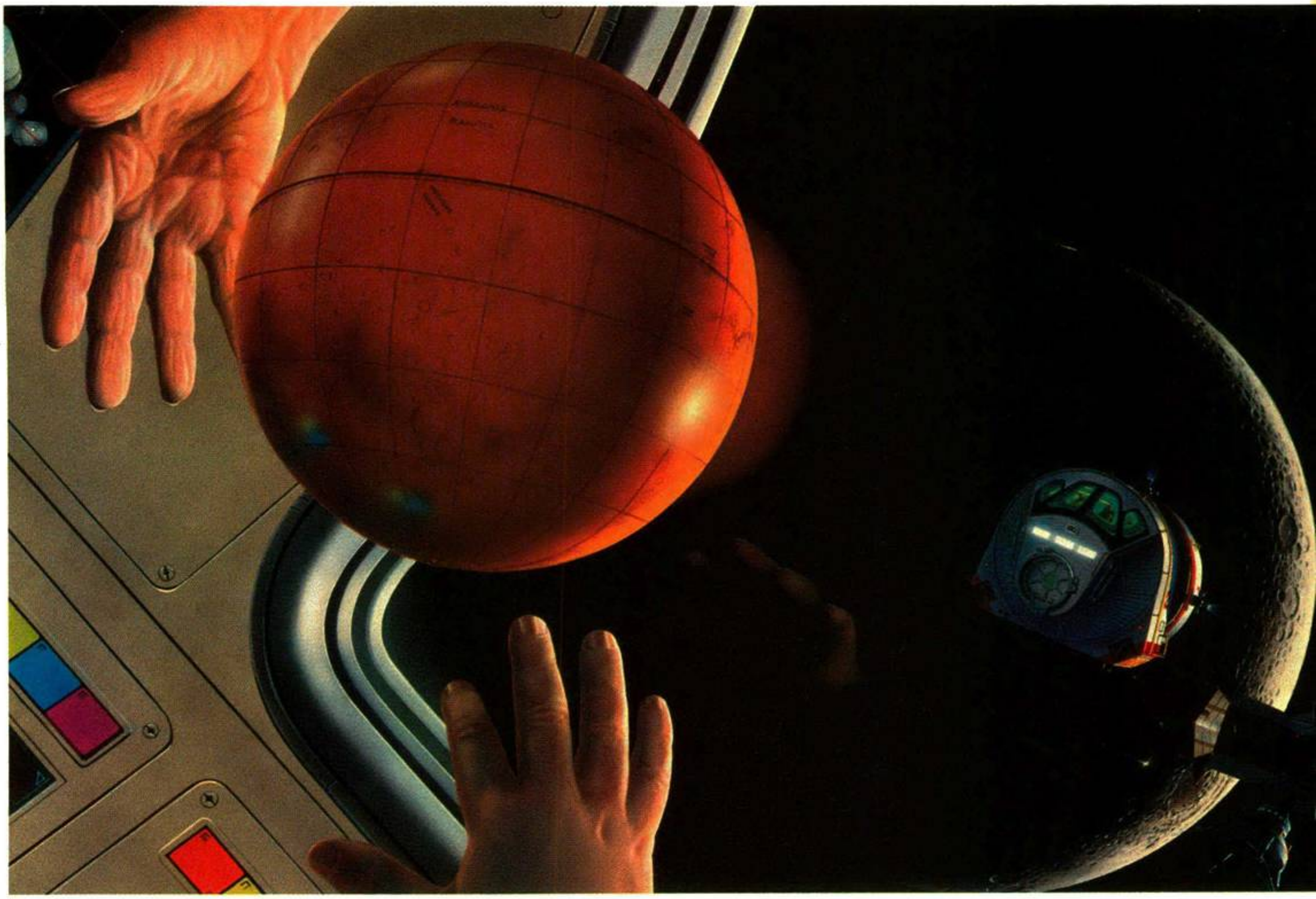
After the political collapse of President Bush's Space Exploration Initiative, NASA did not abandon deep-space exploration completely. The agency still maintains a small study office, called the Mission From Planet Earth. Its director, Carl Pilcher, says, "Our responsibility is to develop NASA's longterm planning for space exploration and development, writ large," over several decades.

Pilcher admits that after the heady days of the Space Exploration Initiative, NASA's not exactly showering his office with money: "Our budget is very small. It's basically just me and my deputy and a secretary, and we will have several people joining us. One is in education and outreach."

But Pilcher argues that lots of money is not what Mission From Planet Earth needs. "The key issues are not how we are going to get back to the Moon. The key issues are why is this nation going to return to the Moon and what are we going to do when we get there? Those questions can't be answered by NASA itself. They're questions that have to be addressed by our society as a whole."

Asked about people who hoped humans might return to the Moon in their lifetimes, Pilcher says, "I understand the frustration. We're trying to change the program in a way that would help address some of that frustration." If society as a whole is behind a lunar mission, he says, it will happen.

Supplying the Gold Rush made San Francisco a city. Could feeding the Space Station make a lunar base possible?



While not endorsing the General Dynamics project, Pilcher said, "Our office acts as an advocate for those kinds of company-proposed activities and that kind of innovative thinking within NASA. I think what General Dynamics did is extremely interesting." However, he continues, a human return to the Moon isn't anything one could ever describe as cheap, no matter how it's done. Pilcher thinks NASA is unlikely to consider seriously a return to the Moon until the Space Station is completed.

So if the government isn't going to go back to the Moon anytime soon, will anyone?

The short answer is, no. But a more accurate answer would be: It may well happen, but not easily, and not fast.

A key advantage is the new international situation. While the end of the Cold War removed much of the drive behind the space program, it also removed what many perceive as the most imminent threat to human survival. In today's world, there is simply more time to expand into the solar system.

Recall the long list of cumulative advances at the beginning of this story. Most are small improvements to old technologies that over time accumulate into major changes. Of the new technologies, a few are military but most arose in support of NASA's scientific requirements — or they are commercial, some coming from government support of commercial activities and some from essential services like weather satellites.

This is the long road into the solar system. It's a painfully slow road, but it is also the healthy road. Since every advance has a specific reason, there's less danger that changing politics will cancel the program. No matter the political landscape, the United States, Russia, the Europeans, Asian countries, and several developing countries are all likely to continue launching improved communications, remote sensing, and weather satellites. These require improved launchers and upper stages. Better vehicles let you do more in space.

Will the space industry's expansion remain slow? Unlikely. Commercial space earns the United States over $5 billion per year, and this number is rising fast. That money is just beginning to attract more money.

Space program support is always fickle. To develop space, you need sound economic reasons to go there. Luckily, they exist already.

Pat Rawlings, LPI

IF PEOPLE CAN GO TO THE MOON, they can go to the planets because the techniques are largely the same.

Would-be space industrialists have to be idealists, since it takes years to make money. But they do exist. Over a decade ago, one now-successful company was started from scratch by three business majors just out of college. Orbital Sciences Corporation developed the innovative Pegasus air-launched rocket that tested the market for small, inexpensive launchers. They did it without direct government money. The Advanced Research Projects Agency promised to fly a small number of science and technology missions, which allowed the company to raise money in the commercial marketplace.

Other Orbital Sciences Corporation projects include upgrading the Pegasus, a medium-sized launch vehicle based on Pegasus called Taurus, an upper stage for the shuttle, a tiny scientific platform cheap enough for some colleges and universities to afford ($10 million per flight), and a global mobile e-mail and fax network. It's a privately funded space program, independent of NASA and the military, except as customers.

Other companies — including giant Lockheed with their Lockheed Launch Vehicle — have followed in Orbital Sciences' steps. Likewise, Italy's Spacehab used a promise from NASA and money raised by Chase Manhattan Bank to develop and fly a commercial scientific laboratory in the shuttle.

Pegasus demonstrates that launch vehicles remain the bottleneck. Reduce costs and payloads appear. Says General Dynamics' Caudle: "It's the chicken and the egg. No company's going to build a payload until they have a launcher that can lift it — and no one's going to build a launcher until they have a payload to pay for it."

The key to breaking out of this may be the Space Station. If built, the Station will be the first big permanent facility in Earth orbit. It'll require a large quantity of supplies and equipment delivered day in and day out. Outside of NASA, no one seriously believes the shuttle is capable of fulfilling this need. The Space Station thus becomes the first large market for commercial launch vehicles.

You could call this the San Francisco model of space development. San Francisco was established by the Spanish as a military base in what was then an extremely remote area. San Francisco became a city by supplying the Gold Rush.

Once the city was established — for whatever reason — it became a market. A large and growing quantity of supplies had to be delivered from the East Coast. The existence of San Francisco encouraged the government to provide subsidies that helped private companies build the railroads, which in turn built the vast interior of the country.

Likewise, once the Space Station is built — for whatever reason — a large, permanent market will exist for delivering cargo to orbit. This will give companies a reason to invest money in duplicating Orbital Sciences' feat on a larger scale. It will also mean that they can make a profit in a reasonable time, which means more people and organizations may be willing to invest. The railroad to orbit will begin. And once spacecrafts are in orbit, it will be easy for them to get to the Moon: The single-engine Centaur will do nicely.

A long time ago, says NASA's Mendell, "I figured that political support for the space program was inflexible, limited, and highly changeable — undependable, in short. The only things I could think of that are dependable were religion and economics. With economics, I quickly came to the conclusion that there was nothing out there so incredibly valuable that you'd would import it back to Earth. That meant you need an economic scenario that's essentially contained in space."

The key point is that you don't need to find resources out there to deliver back here. All you need is a reason to be out there. While not entirely subscribing to the San Francisco model, Mendell agrees that colonies in the American West provided a need for infrastructure. Unlike what NASA has been trying to do in space, the United States did not build railroads into the mist.

Most of America's largest aerospace companies recently began the Commercial Space Transportation Study, which NASA later joined. According to Caudle, these companies "are going around and interviewing a number of different industries and asking them, 'How cheap does a launcher have to get before you'd use one?'"

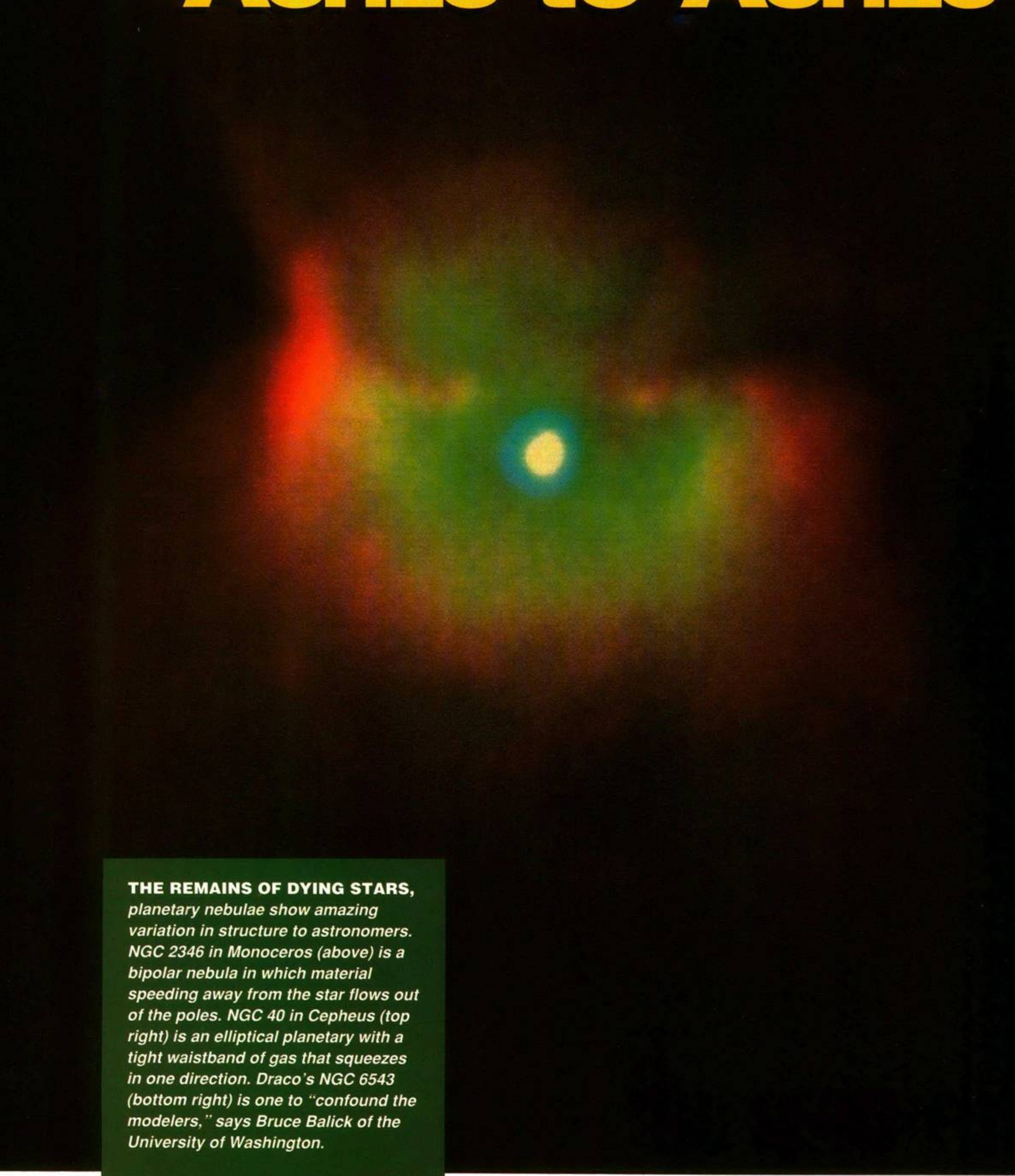
The biggest likely near-term markets for commercial space will surprise you. "My specialty in this study is space burial, putting human ashes in space," says Caudle. "And there's a market for that, believe it or not."

Too strange a use? Well, others believe that tourism will be the second big industry into space after communication satellites. Today, tourism is the world's largest industry and hugely profitable; it's an industry with imagination and a lot of money to spend. The price of sending an astronaut to orbit would have to drop only ten-fold or so to compete with today's cruise ship tours of Antarctica. That kind of cost reduction should be well within reach.

So maybe the next person on the Moon will be me — or you.

Donald F. Robertson is a science writer based in the San Francisco area.

ASHES to ASHES

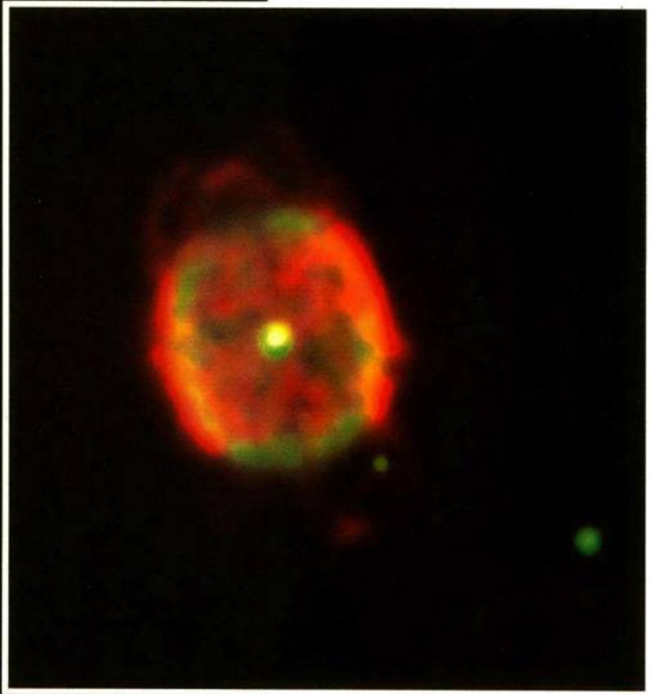


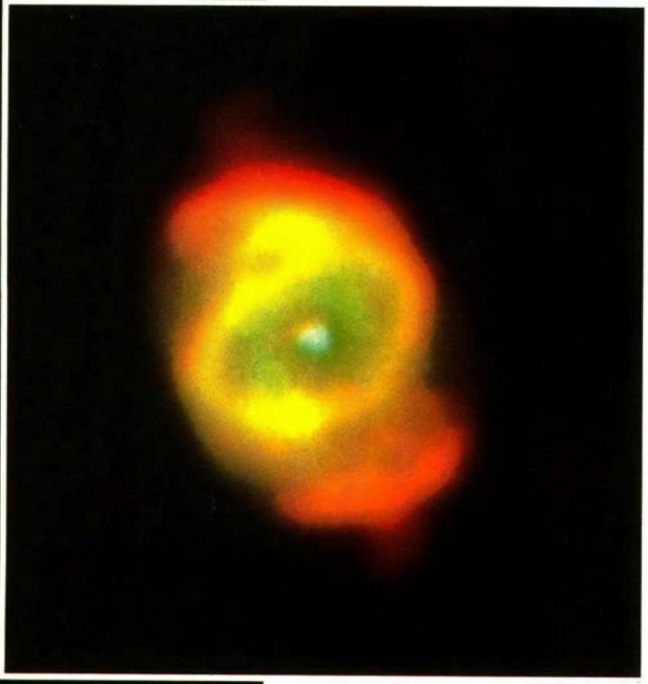
THE REMAINS OF DYING STARS, *planetary nebulae show amazing variation in structure to astronomers. NGC 2346 in Monoceros (above) is a bipolar nebula in which material speeding away from the star flows out of the poles. NGC 40 in Cepheus (top right) is an elliptical planetary with a tight waistband of gas that squeezes in one direction. Draco's NGC 6543 (bottom right) is one to "confound the modelers," says Bruce Balick of the University of Washington.*

and DUST to DUST

Though planetary nebulae were discovered nearly two centuries ago, they are only now showing us more about how most stars die.

by David J. Eicher





Unless otherwise noted, all photos by Bruce Balick/NOAO

The ways of star death are several. Massive stars often die in the bomb blast of a supernova. Lightweight stars slowly fade to black like a cooling ember.

But most stars do neither. Instead, they expire by swelling their atmospheres and then hiccupping them away to produce a gaseous shell called a planetary nebula.

These planetary nebulae offer clues about the now-dead stars that made them. "Those of us who study planetary nebulae need to think like paleontologists," says astronomer Bruce Balick of the University of Washington. "We go back in time to recreate the star that frittered itself away."

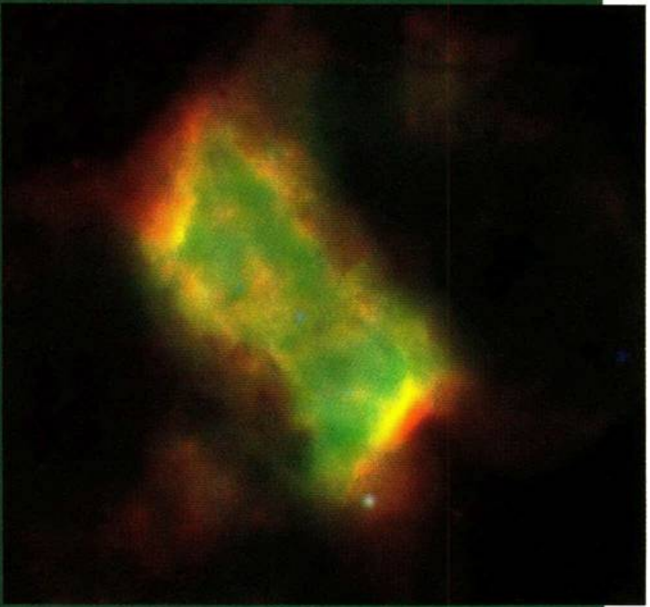
Unfortunately, a star's dying days and the birth of its planetary nebula are usually clouded in dust.

But thanks to some revolutionary thinking, recent advances in observations, and sophisticated computer modeling, astronomers are now gaining a much clearer picture of how planetaries form and disperse into the Galaxy. This pleases astronomers like Balick because planetary nebulae are important objects for understanding how stars die. Planetaries not only show us the endgame of life for a typical star, but also forecast the fate of our Sun and solar system.

Death of a Star

Before we look at the latest findings on planetary nebulae, let's examine how a star evolves into a planetary nebula and what happens as the nebula slowly expands. "We know enough of planetaries to

The false-color CCD images in this article were made with the 2.1-meter telescope at Kitt Peak National Observatory near Tucson. Blue represents gas with the highest ionization energy, green the gas with lower ionization, and red the gas with the lowest ionization.

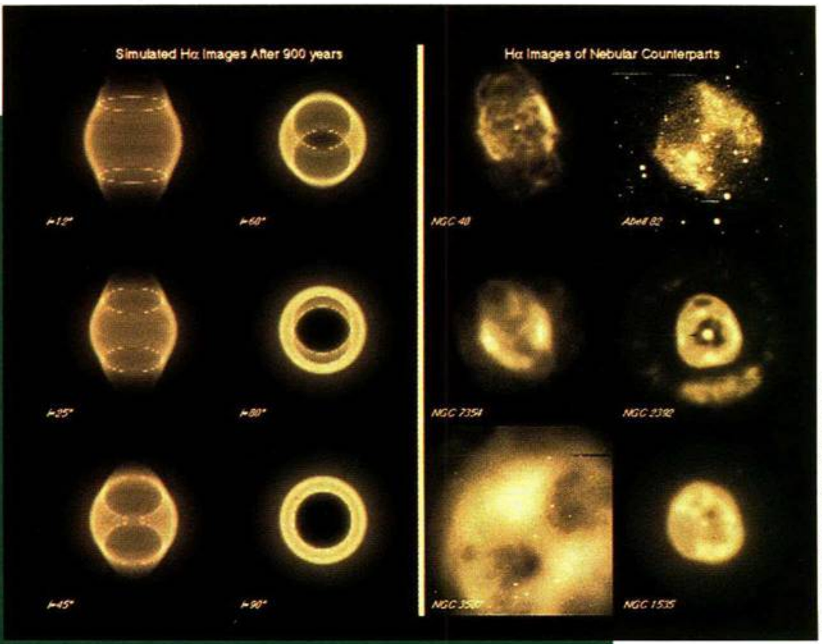


LIKE A BUTTERFLY SPREADING ITS WINGS, *the bipolar nebula M76 in Perseus shows immense lobes of glowing gas. As the star that produced the nebula died, it formed a disk of material. Expanded by the hot star, the star's wind created twin lobes along its poles.*

paint a basic picture," says Balick. If a star has a mass of between about three-quarters and eight times the Sun's, it will follow a pretty predictable path. As the star approaches the end of its life, it exhausts the store of hydrogen used for fusion into heavier elements. It becomes a giant and begins burning helium. The star has a dense core with a slowly expanding, tenuous atmosphere surrounding it.

Among the majority of stars ending their lives this way will be our Sun. When someone speaks of the Sun becoming a red giant and swallowing Mercury, Venus, and Earth in its fiery atmosphere, they are predicting the Sun's distant future. "But not to worry," says Balick, "the Sun won't become a red giant for another five billion years, give or take a few hundred million."

As a giant star like our Sun continues to evolve, it begins burning hydrogen and helium in concentric shells around the core. The star's size and brightness slowly increase. "A planetary nebula begins to form when outward pressure from the light of the central star — called radiation pressure — exceeds the gravitational pressure in the star's atmosphere," says Balick. "A wind casts off the star's outer layers into the surrounding space." This wind carries a great deal of cold molecular gas away from the star at a velocity of about 10 kilometers per second, slow by stellar standards. First, this slow wind comes off the star in an equatorial disk and then gradually expands into a lopsided shell. After only a few thousand years, perhaps 10,000, this wind strips away much of the star's mass.



Adam Frank/University of Minnesota

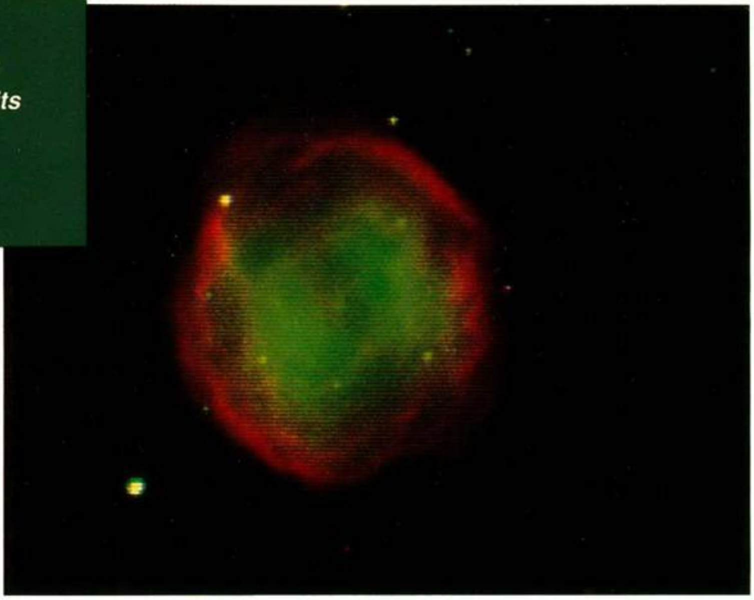
ART IMITATES LIFE *as computer models made by Adam Frank of the University of Minnesota closely match the shapes of real planetaries observed in the sky. Such close matches reassure astronomers that they understand the principles at work in planetary nebulae.*

What triggers the slow wind? Astronomers do not yet know whether radiation pressure alone does the trick or if it acts in tandem with the pulsations known to occur in these evolving stars. The latest model suggests that pulsations first levitate material from the star. This star stuff anchors on dust particles orbiting the star, and these dust particles help drag away the star's gas.

When the star is down to perhaps two-thirds of a solar mass, the slow wind shuts off. The planetary nebula now begins to form. The star, stripped close to its hot core, becomes furiously brilliant. With its hot fusion heart exposed, the star emits a fast wind. Radiation pressure created by the high temperature casts whatever material is left outward at velocities of 2,000 to 4,000 km/sec. In a cosmic instant — maybe 1,000 years — the star switches from producing a dense, slow wind to a fast, tenuous wind. The star now resembles a white dwarf, a collapsed star so dense that one teaspoon of its material would weigh a ton or more on Earth.

"Although the germ of the planetary's shape exists early on," Balick says, "the fast wind sculpts the planetary into the shape we see in visible light." Catching up to the slow-moving material, the fast wind slams into it and creates a shock front. At about the same time, the stripped, hot star bathes the material in radiation, ionizing it and causing it to glow. This is what allows us to see a planetary nebula. We can see a planetary only when its core is hot enough,

INTENSE RADIATION *from the central star excites a planetary nebula's gas into glowing, as with the elliptical planetary NGC 7139 in Cepheus. The bubble of gas gets its shape from interaction between slow and fast winds of material coming off the star as well as from the star's blazing energy.*



on the order of a few tens of thousands of degrees, to make it glow. This occurs as the star's hot core is exposed and lasts only as long as the star remains hot enough, perhaps a few tens of thousands of years.

But unlike the classic picture of a smooth, round, symmetrical shell that constitutes a planetary nebula, about 85 to 90 percent of those observed have shapes far less symmetrical and more complex. In 1987 Balick and his collaborators decided to find out why.

Conducting a Stellar Autopsy

A new and improved picture of the life of a planetary has emerged from observations made by Balick and from theoretical calculations made by Adam Frank, then a graduate student at the University of Washington and now a colleague at the University of Minnesota. Recognizing that most planetary nebulae aren't round, Balick proposed that something beyond the interaction of a slow spherical wind and a fast spherical wind was needed to explain the shapes seen. Thought Balick: What if the slow wind comes from the star's equator so that most of the ejected mass lies in a plane or disk around the star?

"If that's the case," says Frank, "then once the fast wind turns on, it will run into dense material around the equator. Though it slows down at the equator, it will speed forth unhindered above the poles. This would produce an elliptical or bipolar object, and this is exactly what we see in the vast majority of planetary nebulae." Balick proposed that astronomers can thus explain virtually the entire spectrum of shapes they see in planetary nebulae. Balick, Frank, and their collaborators Vincent Icke and Garrelt Mellema of Leiden University have taken on the task of producing sophisticated computer models that detail how planetary nebulae work.

"I got into this when I was at the Goddard Institute for Space Studies in New York," Frank says. "I was looking for a Ph.D. project when Bruce Balick told me he was searching for a theorist to do numerical simulations of how planetaries expand." So began a collaboration that has in large part rewritten the picture of how planetary nebulae evolve.

"Planetary nebulae are interesting because they give us a place where we can study rather violent examples of gas dynamics," he says. "Some of the gas is moving at 10 km/sec and other gas is moving at 1,000 km/sec, giving you a natural laboratory in which to watch the interactions."

If the shock fronts between the shells made up the whole picture, says Frank, they would be valuable enough for a lifetime study. "But we also see a wide variety of shapes in planetaries, a range of gas sculpture, from ellipticals to bipolars to narrow, focused jets, that is far more complex than anyone previously imagined."

Modeling the gas dynamics of planetaries has led astronomers to focus on two questions. First, why do planetaries have the shapes we see? Second, what processes go on inside planetary nebulae? To tackle these questions, Frank takes a Cray Supercomputer, inputs what we know about the physics of gases in motion, and then lets the simulation develop in accelerated time. The key variables of the model are the rate at which a star loses mass and the speed of the winds that disperse the material outward. The basic goal is to use the computer's incredible power to animate the equations that govern the life of a planetary nebula and to compare the simulated results with what we see in the Galaxy.

The biggest challenge was to explain the lopsided nature of some nebulae. "We work with an interacting stellar wind model," explains Frank, "to make the aspherical, or

A HOT BUBBLE OF GAS *constitutes Abell 30, an unusually spherical planetary nebula. In this image, unlike the others in this article, blue represents low-energy material and yellow moderately ionized gas.*

lopsided, slow wind and the fast wind collide in a shock wave to give us the nebula we observe. The question then becomes, Can we reproduce the various shapes of planetaries we see on a computer? The answer is yes." Frank and Mellema invented a way to simulate a disk of material, driven by the slow wind, that gradually spreads and then much later interacts with the fast wind. Frank tested the model by tilting it to simulate different orientations of planetaries in the sky. This yielded a set of computerized planetary nebulae that resemble known objects to an astonishing degree. (See the illustration on page 40.)

The similarity suggests two things. First, computer modeling can show what happens in real planetaries. Second, nature in shaping planetaries follows a predictably simple and repetitive course of action, just as it does in other parts of the universe.

"We find that if the mass of material at the equator is twice or more that at the poles, the planetary will be strongly bipolar," says Frank. "If it's less than that, you'll get some sort of elliptical shapes." In the end, the numerical simulations conducted by Frank confirmed Balick's speculations.

A Second Opinion

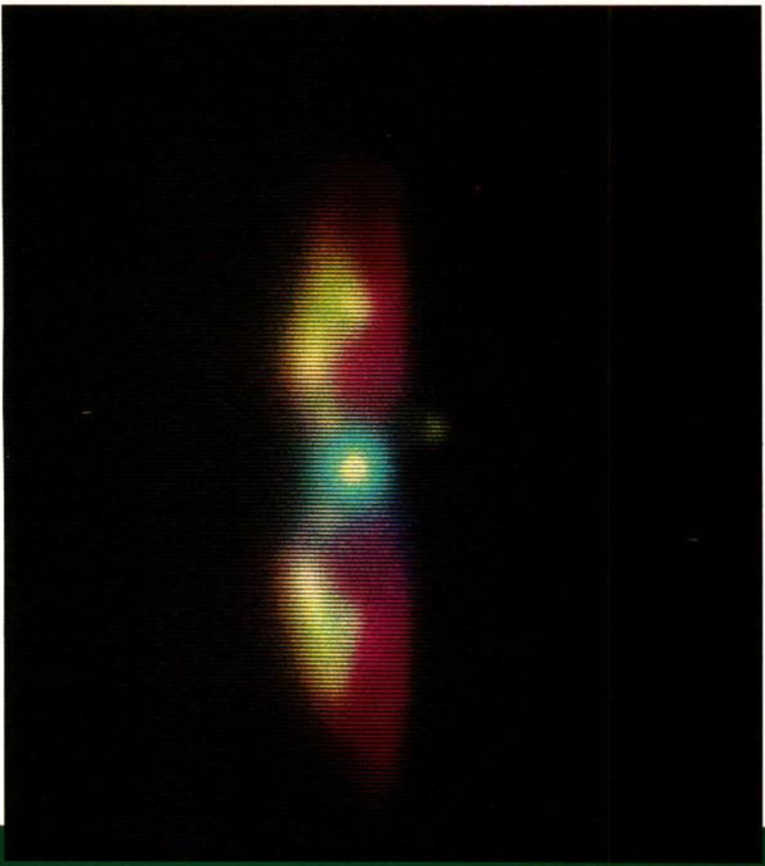
Frank's simulations produced a few surprises, too. "We found a way to make jets," he says. A year or so later Noam Soker of Haifa University, Israel, and Mario Livio of the Space Telescope Science Institute in Baltimore proposed that planetary nebulae ought to be added to the list of objects that can produce jets, a list that includes protostars, supernova remnants, X-ray binary stars, and high-energy galaxies. That followed some observations of what appeared to be jets in several planetaries.

Then Livio suggested another influence may be at work. He believes that many planetary nebulae are or were part of a binary system. Livio's model suggests that the orbital motions of the stars produce the right kind of energy needed to generate an aspherical slow wind in some planetaries. "This happens as the companions become absorbed in a so-called common envelope phase," says Livio, "a period in the aged stars' lives when the two share an atmosphere." While astronomers don't see many planetary nebulae with binary nuclei, Livio thinks that even Jupiter-sized planets could provide the energy needed to cast off the slow wind in an aspherical shape.

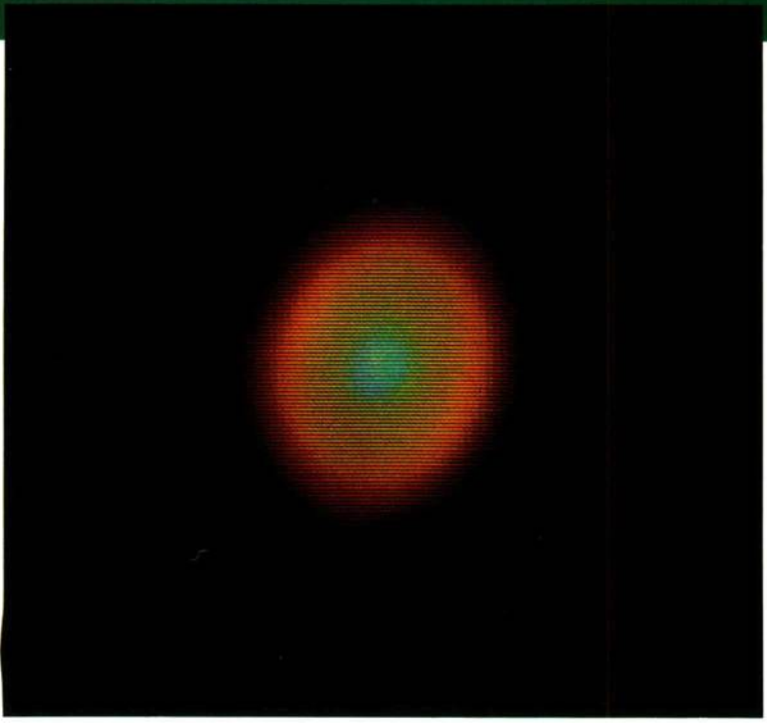
"This is the next frontier in planetary nebula research," says Frank. "And Mario has the best possibility of the mechanism that might make the slow wind aspherical."

But astronomers will not know whether this idea is valid or not for some time because the phenomenon is simply so hard to observe. However, Howard Bond of the Space Telescope Science Institute and other astronomers have observed binary nuclei in some planetaries.

"How do you form such a system?" asks Livio. "It should be difficult to make such a system because the star that ejected the planetary nebula must be an enormously extended, bloated star. Yet we find ten or fifteen examples where the central stars have very short orbital periods, sug-



THE CONTRAST IN HISTORIES *couldn't be greater between Minkowski 2-9 (above) and IC 418 (below). A dense disk of material around M 2-9's equator focused the outrushing material into a pronounced bipolar nebula. IC 418, on the other hand, is a classic spherical nebula produced by a smooth outer expansion.*



ENCLOSED IN AN ANCIENT TOMB, *a bright shell of material designated NGC 6894 glows from the intense power of the stripped, central star. The fainter, outer wrapping of gas is the remnant from the star's older slow wind.*

gesting they are extremely close together, and therefore *small.*" Livio suspects that the stars Bond and others observed did not have their companions at such close separations when they were very large.

"The stars probably started far apart and went through a common envelope phase," he says. If so, then the core of the giant star and its secondary spiral in close together and produce the energy to eject the common envelope into space.

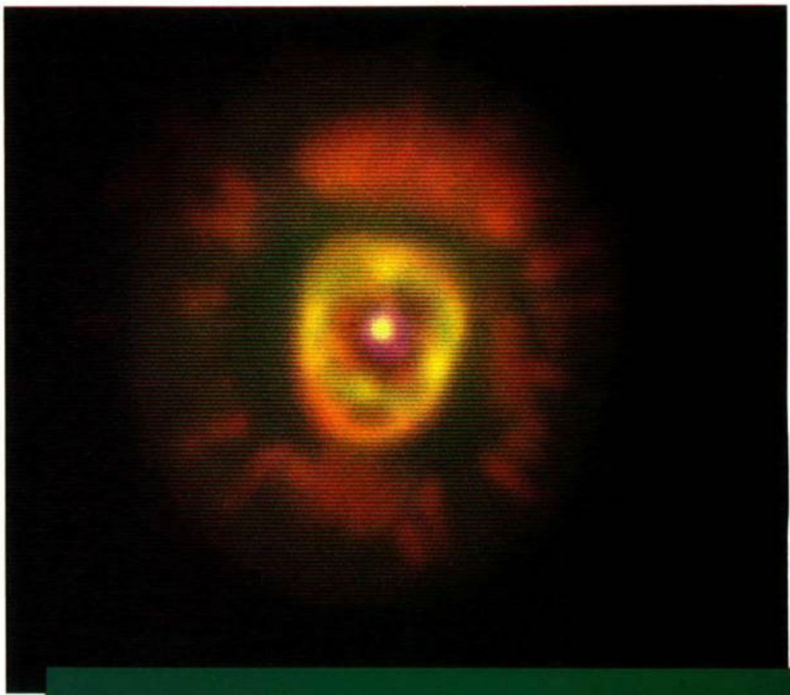
"This process is important not only in forming planetaries," says Livio, "but also in making cataclysmic variables and binary pulsars."

A binary nucleus helps explain the difference in density between a planetary's equator and poles. "When we calculate the physics," says Livio, "we find that the material ejected by these binary nuclei is ejected in the orbital plane." That is, a great amount of material builds up around the star's equator. Says Livio: "We have a natural mechanism that forms the density contrast we have all been seeking." This is at least one of the ways, he stresses, to explain why planetaries are denser around their equators.

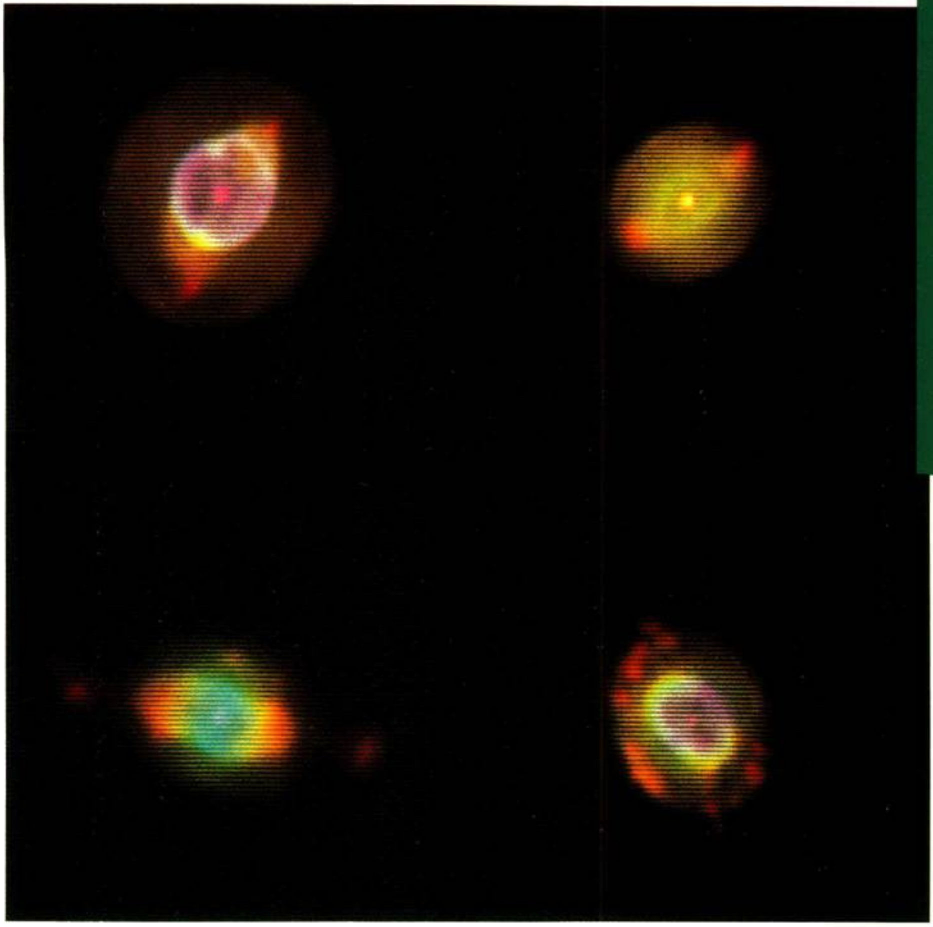
Adding to the theory's significance, Livio suggests that perhaps a large number of planetaries, if not the great majority, now have or once had binary nuclei. There's a twist to this, however. Left to its own devices, the giant star and its envelope should not rotate at all. But a young planetary nebula could be "spun up" so it rotates, producing the density contrast. But left to its own devices, the giant star and its envelope should not rotate at all.

"If the star has a companion of very low mass," says Livio, "one about ten times the mass of Jupiter at about Jupiter's distance from the Sun, then the system's tidal interaction could make the star and the envelope rotate." Because of the rotation, the gas dispersing from the star would concentrate in the orbital plane. Livio thinks it's also possible, but less likely, that magnetic fields might play a role in the process.

Unfortunately, it is difficult to see stars enveloped in a common envelope. The envelope "looks just like a huge star," says Livio. Inside the envelope, the binary nucleus is doing its thing, but it's outside the current realm of detection. "The spiraling-in phase of the common envelope scenario lasts only a very brief time," says Livio, suggesting another detection problem. "It may last only hundreds or a few thousand years." Despite this, V Hydrae, a bright star in the southern constellation Hydra,



THE ESKIMO NEBULA *in Gemini (NGC 2392) depicts the brilliance of the central star and complexity of interaction between various layers of gas. The old, slowly expanding material forms a "parka" and the highly energized, faster material inside it the "face" of an eskimo, a familiar sight in observatory photos.*



IT'S A TOTAL MYSTERY *when astronomers come to the subject of "FLIERs," or fast, low-ionization emission regions. These jets, visible as red lobes on either side of the centers of these planetaries, are shooting away from their progenitor stars at supersonic speeds. This makes no sense, nor does their low ionization. The fiercely hot central star should "cook" them into higher levels of energy.*

may be a common envelope object "caught in the act." It rotates rapidly and has a subtle, bipolar structure — possible signs of a planetary nebula in the making.

Should Livio's "common envelope" idea carry the day, it suggests the Sun will become an aspherical planetary nebula. The aspherical nature of the Sun's slow wind would be caused by Jupiter. We'll end up inside some kind of planetary with an ellipsoidal shape, but not one of the more extreme bipolar objects.

"The Sun's atmosphere will extend out to Mars, or perhaps beyond," says Livio. But Balick and Livio caution, "Forecasting the details of what exactly will happen with the Sun's planetary nebula requires a great deal of knowledge about the Sun's internal structure which we do not yet have." That a planetary nebula will form is fairly certain, says Balick, but it's too soon to predict the details of what it will be like.

Strange Symptoms

The exact fate of the Sun isn't the only unknown in planetary nebula research. Balick and colleagues were completely surprised by their discovery of high-velocity, narrowly focused jets, particularly in the bright planetaries NGC 3242, NGC 6543, NGC 6826, NGC 7009, and NGC 7662. Some of these differ from the more normal jets studied by Noam Soker and Mario Livio. The high-velocity jets are small knots appearing on opposite sides of the centers of such elliptical planetaries — indeed, in the case of NGC 7009, they are prominent enough to give the object its sobriquet, the Saturn Nebula. Called fast, low-ionization emission regions (FLIERs), these jets are perplexing for two separate reasons. They appear to be coming out of the central stars of planetaries at supersonic velocities — speeds far greater than astronomers can make sense of — and their spectra show they are barely ionized. Basking in the intense radiation of the stripped central star, they should be highly ionized, just like the rest of the nebula in which they lie embedded.

"We could not understand this at all when we finished a kinematic study of the FLIERs," says Balick. "Their velocities were wildly supersonic — on the order of 30, 40, 50, or more km/sec. As a comparison, the speed of sound in a planetary nebula is a mere 10 km/sec. These things ought to appear like bullets ramming through the older material." Adding to the mystery, Balick emphasizes the small, focused nature of the FLIERs. "If you puncture a balloon, you expect the gas streaming out of the tiny hole to stay focused in a jet for a short distance and then diffuse in eddies and vortices into the surrounding medium," he says. Yet FLIERs appear to hold together as small, narrow jets over relatively long distances. "Also, their low ionization remains a real enigma," says Balick. "The ultraviolet photons from the central star ought to ionize this material several times over."

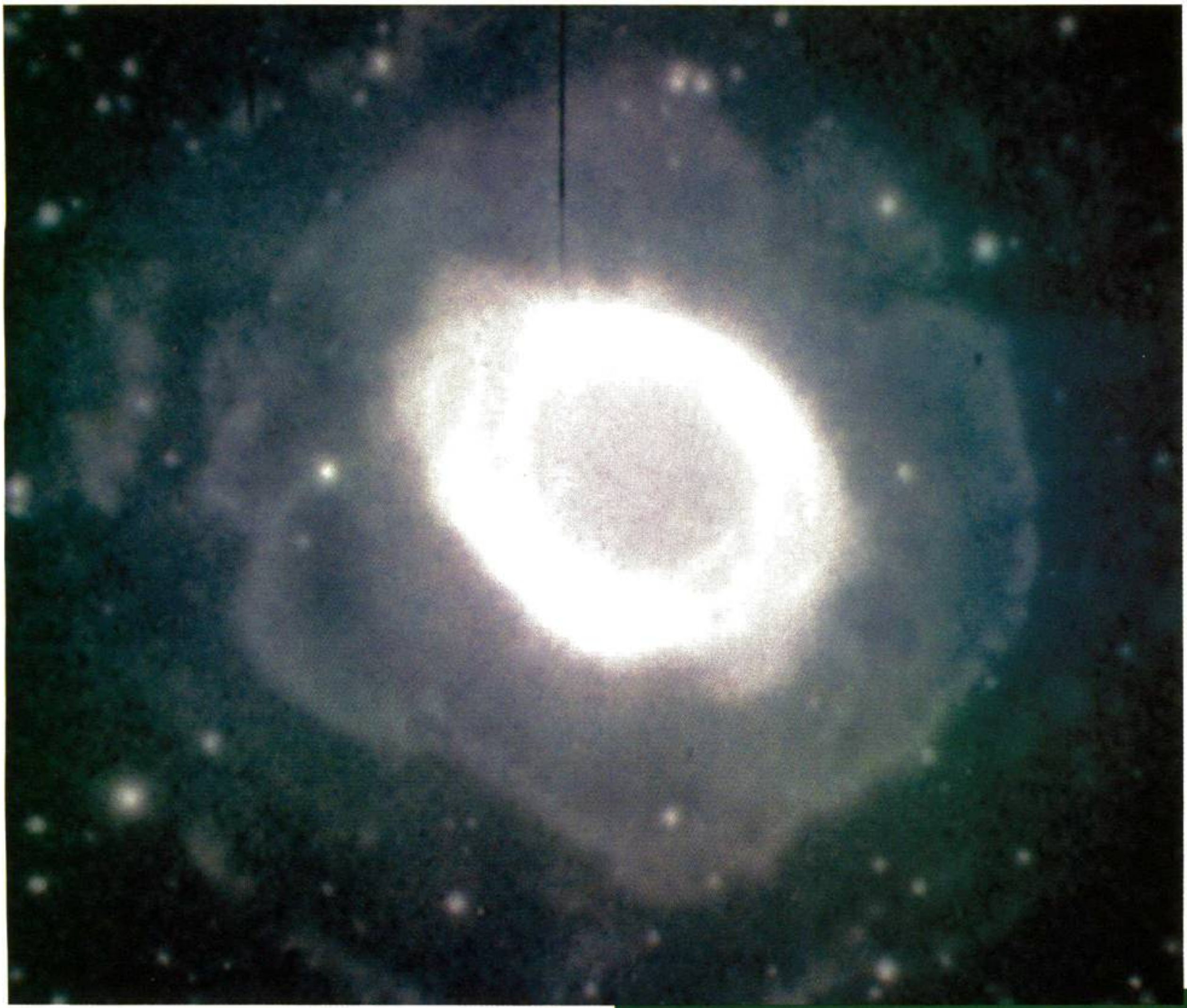
More recently, Balick and his collaborators have discovered that FLIERs are rich in nitrogen, containing five times as much as the rest of the surrounding nebula. This argues that they are spitballs formed from material deep inside the star and flung outward.

"No theoretical model has anticipated such bizarre behavior," says Balick. "If I were a stellar theorist, I might find this a good time for a tall bottle of strong wine."

Another peculiarity came out of research by Balick and George Jacoby, an astronomer at the National Optical Astronomy Observatories in Tucson. Balick and Jacoby's deep, wide-field images of some planetaries showed extremely large, faint outer shells of gas surrounding some of the objects.

"What this suggests is that some planetaries undergo periods of casting off shells of material," says Balick. "Planetary nebulae are not necessarily one-time events but may be episodic. The star becomes a giant, blows off its material, and about the time that material has expanded to become the halo we see, the central star has returned to the stage where it can blow out a second envelope, which forms the bright, inner part of the planetary."

For relatively massive stars, Balick suggests, the process may be cyclical. If a star spends a million years as a giant, it may undergo two or more periods of mass loss, tossing off



George Jacoby/NOAO

THE RING NEBULA *is not really a ring at all, but an hourglass-shaped bipolar object seen end-on, according to some astronomers. Others believe it is a ring and that the faint outer haloes surrounding it are the "smoking gun" indicating an earlier event when material streamed off the central star.*

several shells of matter into the Galaxy. "The halos may be tracers of an earlier era of mass loss in these objects," says Frank. On average, the events may be separated by 10,000 or more years. Recent infrared observations by Wil van der Veen of Columbia University appear to confirm the episodic nature of mass ejection in these stars.

A particularly striking image of the Ring Nebula in Lyra (M57) made by Jacoby, for example, shows these outer shells quite well (see above). In another recent and unusual development, Joel Kastner of the MIT-Haystack Observatory and Ian Gatley of the National Optical Astronomy Observatories studied the structure of the Ring Nebula and found it's not simply a shell of material around the central star that appears ring-shaped. This common sense, traditional view appears to be wrong. Instead, the Ring Nebula is a bipolar nebula with hourglass-shaped lobes seen "end on." This view of the Ring was proposed as far back as 1961 but demonstrated most recently and most successfully by Kastner and Gatley. Additionally, Kastner and Gatley think the older shells may be near and far lobes of the bipolar nebula and not the result of episodes of mass loss. If this is so, the idea may conflict with the interpretation by Balick and van der Veen, and more observations will be required to solve the puzzle.

Astronomers' knowledge of the Milky Way's coterie of nebulae has expanded quietly over the past few seasons. Exploring planetaries will take us closer to an understanding of how most stars in our Galaxy and throughout the universe go about their lives. We'll gain a more detailed picture of the twilight years of these stars and construct a concrete picture of their demise. We'll gain a better appreciation of how gases interact in the tenuous realm of the Milky Way and what powers and shapes some of the prettiest forms we can see in a dark night in our backyard telescopes. We'll see astronomers attempt to unravel the apparent mystery of the FLIERs. We'll see models depicting exactly how planetary nebulae work snap into crisp focus as they illustrate many now-mysterious processes.

We will witness all this as we see planetary nebulae come into the forefront and gain the recognition they deserve as some of the most revealing objects in the universe. □

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Ideal for lunar and planetary study, plus it's a powerful terrestrial telescope. 900mm f.l, 6x30 finder; star diagonal ; two eyepieces, equatorial mount; setting circles; tripod; and lighted accessory tray.
#9076 **$344** (13.22)

SpaceProbe II 4.5" Reflector
Great 4.5" f/8 reflector, ideal for planetary and deep space. Equatorial mount, slow motion controls, setting circles. 6x30 finder plus 25mm (36x) and 9mm 1.25" eyepieces. Deluxe tripod.
#9078 **$399** (22.19)

Sky Explorer II 80mm Refractor
Perfect for planetary and lunar observation. Bigger equatorial mount than competitive models, two 1.25" eyepieces, 6x30 finder, star diagonal, deluxe tripod and accessory tray.
#9077 **$497** (32.66)

Quality Components For Building or Upgrading

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced!

Standard Primary Mirrors
Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors
Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.
See catalog for pricing.

Elliptical Secondary Mirrors
Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with standard or high reflectivity Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis.
See catalog for pricing.

6x30 Achromatic Finder Scopes
6x30mm—Same unit used on $1000+ "big name" telescopes. With 2-ring bracket, fits scopes 6"-12".
#13023 (white) ***$49.95*** (3.41)

6x30mm Right Angle—90° prism for right-angle viewing. Includes bracket.
#13021 (white) ***$64.95*** (3.41)

Large Aperture Finder Scopes
These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube.

8x50mm—2.7x light grasp of 30mm models. Bright 6.25mm exit pupil.
#7090 (white) #7094 (black) ***$64.95*** (3.41)

8x50mm Illuminated—Wireless illuminator with adjustable brightness.
#7092 (white) #7096 (black) ***$89.95*** (3.41)

9x60mm — 44% more light grasp than 50mm models.
#7091 (white) #7095 (black) ***$89.95*** (3.41)

9x60mm Illuminated—Wireless illuminator with adjustable brightness.
#7093 (white) #7097 (black) ***$129*** (3.41)

Mounting Brackets for 50 & 60mm Finders
Unique sliding dovetail design. Super high quality. Fits any scope 6" and over including Celestron & Meade SCs.

8x50mm bracket #5040	***$34.50*** (2.45)
9x60mm bracket #5041	***$39.50*** (2.98)

Rack-and-Pinion Focusers
Finest in their class! Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.
1.25" #13007 ***$49.95*** (2.98)
2.0" includes 1.25" adapter.
#13003 ***$89.95*** (3.95)

Low-Profile Focusers
Perfect for fast optical systems. Ideal replacements for "Odyssey" scopes.
1.25" #13014 ***$39.50*** (2.45)
2.0" #13016 ***$59.50*** (2.98)

Huge Selection of Astronomy Binoculars

50mm Orion Observer™ II Binoculars — 7x, 10x, & 12x
Fine quality, moderately priced binoculars, excellent for both astronomy and daytime observation. Fully coated optics, unique hand strap for a secure and comfortable grip. Include case and straps.

7x50 #9643 ***$89.50*** (4.44)
10x50 WA #9644 ***$94.50*** (4.44)
12x50 WA #9645 ***$89.50*** (4.44)

50mm Explorer™ Binoculars
High performance large diameter binoculars with BAK-4 prisms and multi-coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design. Include case and straps

7x50 #9306 ***$117*** (4.44)
10x50 #9308 ***$127*** (4.44)

10x50 Orion UltraView™
The perfect binocular for eye and sunglass wearers. Extra-long 22mm eye relief and unique rubber pop-down eyepiece guard allows viewing with or without eyeglasses. Fully multi-coated optics provide high light transmission and maximum contrast compared to standard coated types. BAK-4 prisms. Wide 6.5° field of view. Close focus 16'. Weighs 32 oz. Includes case and straps.

#9351 ***$159*** (4.95)

10x50mm Orion Vista™
Superb for long distance nature observation and astronomy. The image quality will amaze you even when compared to much higher priced binoculars. Fully multi-coated optics provide high-fidelity true color images without ghousting or other aberrations. Long 16mm eye relief and roll-back eyecups for eyeglass wearers. BAK-4 prisms. 5.3° field of view. Weighs just 28 oz. Includes deluxe hard carrying case, rain shield, lens caps, and straps.

#9353 ***$219*** (5.19)

Orion® 70mm FMC Giants
The standard for hand-holdable astronomy binoculars. Fully Multi-Coated. 33% lighter—weighs only 58 oz.—yet the same brightness and 7mm exit pupil as our 11x80 MC model. Superior 'BCF' body design. Includes: soft rubber eyecaps, tripod mounting adapter, durable hard carrying case, lens caps and straps.

10x70 #9501 ***$277*** (6.97)
14X70 #9494 ***$288*** (6.97)

80mm FMC Giant Binoculars
20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable. #9502 ***$389*** (8.05)

16x80 MC- 45% higher power, excellent for astronomy and daytime observation. Tripod recommended. #9496 ***$389*** (8.05)

20x80 MC-Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required. #9498 ***$399*** (8.05)

Orion® 8x56 Mini Giants
56mm objective lenses gather over 2.5x the light of ordinary 7x35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view. Standard model 33 oz. Rubber Armored for protection from bumps. Weighs 37 oz.

Standard Model #9504 ***$129*** (4.71)
Rubber Armored Model #9627 ***$159*** (5.07)

SuperGiant™ 100mm Binos
Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

14x100 #9495 ***$899*** (29.00)
25x100 #9497 ***$899*** (29.00)
Shipped by FedEx only.

Observing Aids

See our catalog for much, much more—everything you need to make observing easy and fun!

Eyepiece & Accessory Cases
With patented unbreakable latches, die-cut foam inserts. (Inside Dimensions shown)

Small Case
11"x7"x3" #5951
$17.95 (2.78)

Medium Case
12.5"x9"x5" #5952
$26.95 (3.36)

Large Case
16"x11"x5"
#5953
$49.95
(5.19)

Orion® FlexiShield™ Dew Caps
Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.
8" Celestron/Meade SC #4200
$44.95 (2.98)

Other sizes available for scopes 3.5" to 14"—See our catalog for details

Orion® Dew Zapper
Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers—fit all Meade & Celestron 8" SCs DC #3503, AC #3504	***$47.95*** (2.98)
10" Dew Zappers—fit all Meade 10" SCs DC #3506, AC #3508	***$54.95*** (2.98)
11" Dew Zappers—fit all Celestron 11" SCs DC #3510, AC #3512	***$59.95*** (2.98)

Scope Saver Telescope Covers
Keep the dust and dew away with these waterproof nylon covers; drawstring closure with cord lock.
8"Model #15130 ***$33.95*** (2.43)

10"-11" Model Fits Meade 10" and Celestron 11"
#15131 ***$39.95*** (2.43)

Now available for Deep Space Explorers!
Ask about other sizes.

Observer's Chairs
Standard Model—Adjustable height center column and padded seat.
#5935 ***$39.95*** (4.70)
Deluxe Model—Built for professional musicians. Extra heavy duty.
#5934 ***$89.95*** (8.02)

Night Vision Flashlights
An essential accessory for astronomers. Choose from our wide selection.

Astronomer's Flashlight #5701	***$9.95*** (1.79)
Nitewriter Pen #5709	***$8.95*** (1.79)
Hands-Free Flex Light #5707	***$17.95*** (2.43)
Starlite LED Flashlight #5714	***$24.95*** (2.43)
Celestron LED Flashlight #5720	***$21.95*** (2.43)

Accessories

Call Toll-Free For Our Huge 76 Page Catalog and See Even More!

Orion Accessories are absolutely guaranteed to be the finest quality available. Compare them side-by-side with "famous name" products! We buy direct from many of the same sources, always specify the highest quality, and pass along the savings to you! 100% satisfaction guaranteed!

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.

.965" #5268 **$26.95** (2.98)

1.25" #5264 **$28.50** (2.98)

Hybrid 1.25"/.965" #8782 **$28.50** (2.98)

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.

#5262 **$38.50** (2.98)

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.

#7012 **$44.50** (2.98)

Extension Cable for Slow Motion Control

12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.

#5014 **$15.95** (2.43)

Tele-Extenders

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

Standard Tele-Extender #5125 **$27.95** (2.98)

Variable Tele-Extender #5127 **$37.95** (2.98)

T-Adapters

Threads to rear cell of telescope, requires t-ring for your camera model.

for SC #5116 **$26.50** (2.98)

for C-90 #7115 **$29.95** (2.98)

T-Rings

Available for many different camera types, call toll-free or see our catalog for your particular model.

45° Erect Image Diagonal Prisms

See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.

1.25" Diagonal #8790

.965" Diagonal #8791

Hybrid 1.25"/.965" Diagonal #8792

$44.95 (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagonals let you view at a right angle from the direction your telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.

1.25" Star Diagonal #8763 **$46.95** (2.98)

.965" Star Diagonal #8761 **$28.95** (2.98)

Hybrid 1.25"/.965" Star Diagonal #14008 **$31.50** (2.98) (2.)

2" Prism/Mirror Diagonals

2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.

For refractors #8770

For Schmidt-Cass. #8771 **$199** (4.71)

2" Mirror Diagonal– Affordable, high-quality star diagonal.

For refractors #8773

For Schmidt-Cass. #8772 **$99.95** (3.45)

Sky Wizard™

Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

- Find any celestial subject in 15 seconds!
- One minute setup — no polar alignment or levelling.
- Observe hundreds of objects in a few hours!
- For ANY telescope, with or without a motor drive. *Even altazimuth or Dobsonian scopes!*
- Digital display of celestial coordinates (RA & Dec).
- Built-in electronic sky catalog — find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Sky Wizard Model 1

Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets. #7801 **$199** (4.11)

Sky Wizard Model 2

Huge 2100+ object database, plus a user catalog to store 27 objects of your choice. #7802 **$319** (4.44)

Sky Wizard Model 3

Gigantic 10,000 object database, expanded subject descriptions, RS-232 port. #7803 **$469** (6.78)

Complete system requires Sky Wizard Model 1, 2 or 3 and a telescope installation package, sold separately.

Installation Packages

Includes 2 encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions.

Installation packages are available for most telescope models. Call for details.

starting at **$177** (5.29)

Encoders and cables also available separately for custom installations. Call for details.

Orion Off-Axis Guider

Allows you to observe a guide star during photography. Multi-coated.

#5144 **$69.50** (3.45)

Orion UltraGuider

Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.

#5139 **$119** (4.19)

110v Motor Drive for Refractors

Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.

#17001 **$72.50** (3.95)

12 Amp Hour Porta Pac Battery

Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.

#2354 **$109** (8.97)

Eyepieces & Barlows

See Our Huge 76 Page Catalog for Many More! Including a Fantastic Selection of Name Brand Eyepieces!
4
2
3b
3c
3a
4
5
1
New!
40mm
✧Sirius™
Plössl

1 ✧*Sirius*™

Plössl 1.25" Eyepieces

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

You could pay nearly twice the price for "famous name" Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces!

Sirius Plössls are top-quality, 50° apparent field (43° 40mm) eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of telescopes. The Classic 4-element Plössl design is renowned for its fantastic performance and has become the standard by which all other eyepieces are compared.

The Fully Magnesium Fluoride coated optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

25mm #8530, ***17mm*** #8531, ***10mm*** #8532, ***7.5mm*** #8533 **$59.95 ea.** (3.45)

New! ***40mm*** #8529 **$79.95** (3.45)

Case only #5911 **$12.95** (2.19)

SPECIAL OFFER–Buy Two or More and Save!

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- *Any 3 .... $30 off (Save $10 ea.)*
- *Any 4 .... $60 off (Save $15 ea.)*
- *ALL 5 .... $85 off (Save $17 ea.)*

Bonus—Free case with purchase of 2 or more!

2 Superb Ultrascopic™ Eyepieces

Unlike other premium eyepieces, Orion Ultrascopics offer complete multi-layer coatings on ALL surfaces, for superior light transmission and contrast. Modern 5- and 7- element designs for pinpoint star images and breathtaking detail. Wide 52° field of view. Guaranteed to beat other brands selling for much more! Unsurpassed high-performance design!

Medium-High Power 5-element

20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 **$74.95 ea.** (3.45)

Wide Field 5-element

25mm #8564 **$89.95** (3.45)

30mm #8562 **$94.95** (3.45)

35mm #8560 **$99.95** (3.45)

***High Power 7-element** —Long Eye Relief*

5mm #8574, **3.8mm** #8576 **$84.95** (3.45)

3 Explorer .965" and 1.25" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated, to maximize efficiency in the various focal lengths. Black anodized, internally blackened, threaded for filters (except 40mm .965").

a *.965 Orthoscopic*

5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583 **$49.50 each** (2.98)

a *.965 Kellner*

18mm #8584, **25mm** #8585 **$37.50 each** (2.98)

a *.965 Achromatic Huygenian*

40mm #8586 **$37.50** (2.98)

b *1.25" Orthoscopic*

5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526 **$54.50 each** (2.98)

c *1.25" Kellner*

6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512 **$39.50 each** (2.98)

4 MegaVista 1.25" and 2" Eyepieces

These outstanding eyepieces feature a 7-element design and incredibly sharp, fully multi-coated optics. The long eye relief and integral rubber eyeguards make these ideal for eyeglass wearers. The extra wide field of view (67°-70°) provides stunning images, perfect for deep space observing.

10.5mm 1.25" #8552 **$164** (3.67)

16.8mm 1.25" #8554 **$159** (3.67)

34mm 2" #8587 **$209** (3.67)

40mm 2" #8588 **$229** (3.67)

Illuminated Reticle Eyepieces

Orion offers 4 versions of the illuminated reticle eyepiece, a necessity for long exposure astrophotography and very useful for polar alignment. All have 1.25" barrels.

12.5mm Plossl Illuminated Reticle

Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.

#8484 **$109** (3.45)

9mm Orthoscopic Illuminated Reticle

Adjustable brightness illuminator. 'Bull's-eye within crosshairs' reticle. Needs 2 SR-44 batteries, not included.

#8488 **$109** (3.67)

SR-44 Batteries (pkg. of 2) #2360 **$5.69** (1.79)

12mm Kellner Illuminated Reticle

Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.

#8482 **$79.95** (3.45)

12mm Kellner Illuminated Reticle

Same as 8482 above except has a wireless illuminator. Needs 2 SR-44 batteries, not included.

#8481 **$99.95** (3.45)

SR-44 Batteries (pkg. of 2) #2360 **$5.69** (1.79)

5 UltraZoom™ 7–21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.

#8556 **$169** (3.67)

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow

Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.

.965" #8740 **$34.95** (2.98)

1.25" #8746 **$44.95** (2.98)

2" #8724 **$89.95** (3.95)

Ultrascopic 2x Fully Multi-Coated Barlow

3-element Ultrascopic lens for superior images and precise color correction. Fully multi-coated optics, black anodized barrel. 1.25 barrel.

#8750 **$64.95** (3.45)

VariPower 2-3x Barlow

Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.

#8748 **$59.95** (3.45)

Shorty Barlows

The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly, and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.

.965" #8710 **$46.95** (2.98)

1.25" #8711 **$54.95** (3.45)

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.

For 8" SCs #7713 **$144** (4.05)

For 10" SCs #7715 **$162** (4.05)

***NEW!** Solar glass filters for Deep Space Explorer reflectors. Many other sizes available—see our free catalog for details.*

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664, 1.25" #5662 **$14.95** (2.43)

Color Eyepiece Filters

Highest quality precision-ground optical glass. Fully anti-reflective coated. Solar system observations are dramatically improved. Thread into the barrel of any standard eyepiece, or directly into a universal camera adapter.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow.

#5510 **$46.95 set** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow. #5514*

1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue. #5516*

1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green.* #5570 **$46.95 each set** (2.98)

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets.

#5517 **$79.95 set** (3.45)

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set.

#5575 **$119 set** (3.67)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow.

#5513 **$84.95 set** (2.98)

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

Enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow absorbs frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum, yielding dramatic results.

SkyGlow Broadband Filters—Photographic and Visual

For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces.

#5660 **$69.95** (3.45)

SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes.

#5658 **$89.95** (3.45)

52mm Broadband Filter–For 52mm camera lenses, (Adapter rings available for other diameters.)

#5668 **$87.50** (3.45)

2.0" Broadband Filter–fits 2" eyepieces.

#5659 **$109** (3.45)

.965" Broadband Filter–fits .965" eyepieces.

#5661 **$49.95** (2.98)

SkyGlow UltraBlock Filters–Visual Only

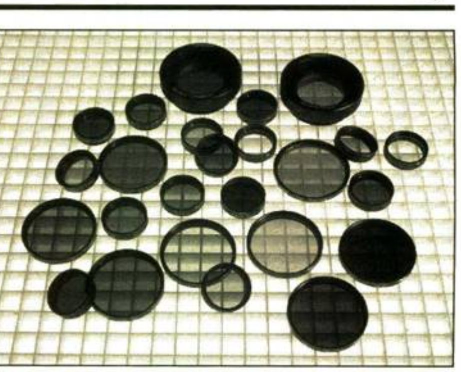
For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces.

#5654 **$87.50** (3.45)

SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes.

#5656 **$119** (3.67)



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If you are not completely satisfied with your purchase from Orion, for any reason.

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- Call Toll-Free and charge to your MasterCard, Visa or Discover Card or send your personal check to order by mail.
- California residents add 7.25% sales tax (8.25% in Santa Clara and Santa Cruz Counties, 8.5% in San Francisco).
- Shipping & handling charge for UPS Ground or US Mail to lower 48 United States are listed in (parentheses) after each price. We ship to U.S. and Canada only.
- We expected the prices in this ad to be accurate for April 1994 at the time of our advertising deadline in January. Prices are subject to change or correction without notice.

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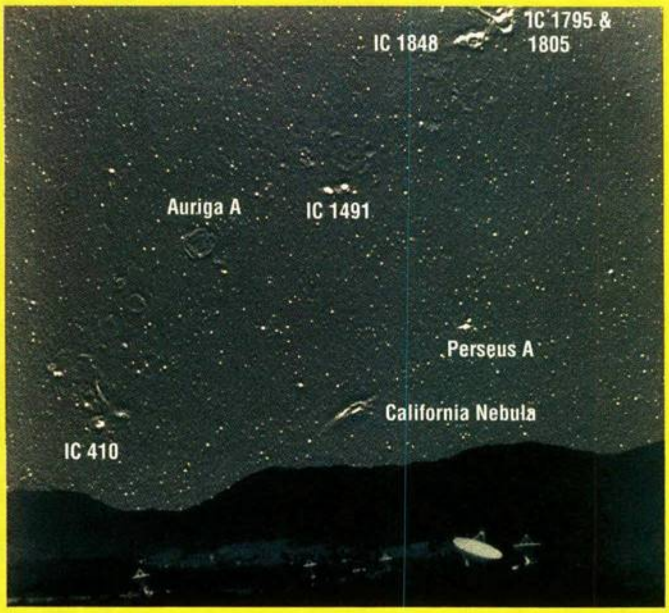
SEEING RADIO

A radio image of the sky looks surprisingly like an optical image. But it reveals a cosmos vastly different from the one we're used to.

by Richard Talcott



What would the universe look like if you had eyes 300 feet across that could see only radio waves?

You're looking at it.

A myriad of starlike points litter the sky, with a few larger, brighter regions punctuating the dark background. You might think the radio view is like a deep optical photo, one showing large, bright emission nebulae surrounded by countless stars. But the two could hardly be more different.

The photo at right is a composite of two images shown at roughly the same scale. The radio image of the sky depicts a region about 45° wide centered in the constellation Perseus. It is the first high-resolution radio view that covers such a wide area. The foreground image shows the telescopes of the National Radio Astronomy Observatory in Green Bank, West Virginia, photographed in visible light. Use the photo above to identify the brightest objects in the radio image.

Astronomers observed this part of the sky in both 1986 and 1987 with the observatory's 300-foot antenna working at a frequency of 4850 megahertz. (The scope, which collapsed in November 1988, appears second from the right in the foreground.) According to James Condon, who led the group of astronomers that observed this region, the team had finished analyzing one set of observations made a few years before, but had just recently completed the laborious process of analyzing the second set. Combining the two sets allowed them to see much finer detail than they would have with either set alone. They chose to show stronger radio emission in lighter shades of gray to more closely match what you would see if you had radio eyes.

The large radio sources that run in a band from lower left to upper right belong to the disk of the Milky Way Galaxy. The bright, irregularly shaped sources are ionized clouds of hydrogen heated by hot stars, as in the California Nebula at bottom center. The faint rings (Auriga A, for example) are supernova remnants expanding into the interstellar gas.

Very few of the "stars" in the image are real stars, however. Most are part of a vast population of extremely distant radio galaxies and quasars. In fact fewer than 1 percent of these starlike objects lie closer than 300 million light-years from Earth and their average distance is a whopping 5 billion light-years. Because radio waves travel at the speed of light, we see these objects as they appeared billions of years ago. Thus the radio image paints a picture of the universe when it was much younger and radio galaxies and quasars dominated the cosmos. □

National Radio Astronomy Observatory

NEW MEADE® ADVANCED PRODUCTS AT LUMICON

"What an astounding combination of high performance and low price!" Jack Marling, Ph.D., owner of LUMICON

TOLL-FREE ORDER LINE 1-800-767-9576
EXPERT INFORMATION 1-510-447-9570 FAX 1-510-447-9589

MEADE APOCHROMAT ED REFRACTORS

7'' f/9
Apochromat
Only
$5495
7'' IN
STOCK!

Meade 6'' f/9 Model 152ED Refractor shown with #1697 Computer.

See the Meade ad in this magazine for full specifications and product descriptions. ED = Extremely low dispersion glass which yields color-free virtually perfect images. PPEC = Permanent Periodic Error Correction "Smart Drive."

Model 102 ED 4'' f/9 Apochromat & mount (add $105 P&S)	**$2195**
Model 127 ED 5'' f/9 Apochromat & mount (add $125 P&S)	**$2795**
Model 152 ED 6'' f/9 Apochromat & mount (add $185 P&S)	**$4495**
Model 178 ED 7'' f/9 Apochromat & mount (add $215 P&S)	**$5495**
Medium format adapters ..... Mamiya 645, **$98;** Pentax 6X7,	**$98**
Med. format EASY-GUIDER™: Mamiya 645, **$298;** *Pentax 6X7,*	**$298**

DRIVE SYSTEMS

#1664 Electronic Drive with PPEC & 2X, 32X slewing system	**$375**
#1697 Computer Drive, 747 object computer memory, automatic slewing to desired object	**$695**
8,000 Object CNGC Library .. **$99** Polar alignment finder ..	**$99**

OPTICAL TUBE ASSEMBLIES (OTA)

Model 102 ED/OTA 4'' f/9 OTA only (add $55 P&S)	**$1045**
Model 127 ED/APO-OTA 5'' f/9 OTA only (add $60 P&S)	**$1595**
Model 152 ED/APO-OTA 6'' f/9 OTA only (add $100 P&S)	**$2295**
Model 178 ED/APO-OTA 7'' f/9 OTA only (add $120 P&S)	**$3250**
Cradle ring assem. 4'' (4½'' OD tube) **$135;** 5'' (5½'' OD tube)	**$145**
Cradle ring assem. 6'' (7'' OD tube) **$169;** 7'' (8'' OD tube)	**$219**

EQUATORIAL MOUNTS

LXD 600 mount and standard field tripod (add $60 P&S)	**$1350**
LXD 700 mount and giant field tripod (add $100 P&S)	**$2250**

NOTE: Add the indicated packing and shipping (P&S) costs to each telescope for insured UPS shipment to your door.

MEADE DOBSONIANS

Drop-shipped from Meade, add shipping charge in parenthesis.

6'' f/8 Starfinder Dobsonian ($39)	**$295**
8'' f/6 Starfinder Dobsonian ($49)	**$395**
10'' f/4.5 Starfinder Dobsonian ($69)	**$565**
12.5'' f/4.8 Starfinder Dobsonian ($79)	**$765**
16'' f/4.5 Starfinder Dobsonian ($45)	**$995***

**Shipped truck freight collect; add $45 packing charge.*

NEW MEADE EYEPIECES

Series 3000 Plossl 1¼'' eyepieces: select 5mm, 6.7mm, 9.5mm, 16mm, 25mm	**$59.95**
Select Any 3 . **$48.95 ea.;** Any 5 .	**$46.95 ea.**
Series 3000 40mm Plossl 1¼'' eyepiece	**$79.95**

Shipping charges of 4-5% are extra.

NEW MEADE 12'' LX200 SCHMIDT-CASSEGRAINS

8'' LX200
$2295

NEW Meade 8'' LX200 Telescopes

See the Meade ad in this magazine for full specifications & details. **LX100 Drive,** 2X, 32X speed control with PPEC (Permanent Periodic Error Correction "Smart Drive") & dual-axis hand controller. **LX200 Drive,** Full electronic control with PPEC, 747 object computer memory and automatic computer controlled slewing to desired object. *NOTE:* A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your Schmidt-Cassegrain.

8'' LX100 Schmidt-Cassegrain with wedge (add $105 P&S)	**$1995**
8'' LX200 Schmidt-Cassegrain with computer (add $105 P&S)	**$2295**
Wedge for photographing with 8'' LX200	**$110**
10'' LX100 Schmidt-Cassegrain w/super wedge (add $145 P&S)	**$2895**
10'' LX200 Schmidt-Cassegrain with computer (add $145 P&S)	**$2895**
NEW! 12'' LX200 (f/10 only) with computer (add $215 P&S)	**$3995**
Super Wedge for photography with 10'' or 12'' LX200	**$395**
8,000 Object CNGC Library (Version 2.5 software)	**$99**
Library Option 1: 10,600 NGC, Messier, IC objects (Ver. 3.2 only)	**$99**
Library Option 2: 64,350 celestial objects (Version 3.2 only)	**$149**

OTHER SCHMIDT-CASSEGRAINS

Meade 2045D 4'' f/10 with motor drive (add $40 P&S)	**$699**
Meade 2080B 8'' f/10 with tripod, wedge, MCOG (add $85 P&S)	**$1149**
NEW! Model 2120B 10'' f/10 w/wedge, tripod, MCOG (add $125)	**$1449**

PHOTOGRAPHY ACCESSORIES

LUMICON Cassegrain EASY-GUIDER 4'', 8'' only, f/6 or f/10	**$225**
LUMICON Giant EASY-GUIDER for 10'' or 12'' f/4-f/10 operation	**$395**

MEADE STARFINDERS

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions and technical specifications for 6'' to 16'' Starfinders. These are complete telescope systems with motor drive, mount, finderscope and 25mm (=48X) eyepiece.

6'' f/8 Starfinder 6(add $65 P&S)	**$599**
8'' f/6 Starfinder 8 (add $75 P&S)	**$699**
10'' f/4.5 Starfinder 10 (add $90 P&S)	**$799**
16'' f/4.5 Starfinder 16 (ship. freight COD)	**$2195**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated shipping charge to the price. LUMICON showroom prices are $99 higher.

ACCESSORIES

LUMICON carries the full line of Meade accessories. See the Meade ad in this magazine for detailed prices and descriptions.

LUMICON Single axis drive corrector	**$99**
LUMICON DX200 Dual-axis drive cor.	**$249**
Meade 47M Dual-axis drive corrector	**$450**
LUMICON DX2BP Dual-axis drive corrector with built-in battery pack	**$299**

LUMICON® SKY VECTOR™

Higher Performance — Lower Price

LUMICON ACCESSORIES

LUMICON, 2111 Research Dr., #5, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- "GUIDE" *mode* leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $399

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $499

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

NGC SKY VECTOR™ $699

IMPROVED!—5500 Additions / Corrections

NGC-Sky Vector™
OFF ON
DIM
MODE
ENTER
UP
DOWN
LUMICON®

Improved NGC SKY VECTOR with over 12,000 object memory including the planets, complete, corrected RNGC catalogue, IC catalogue, *P&K planetary catalogue, & much more!*

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This *zero power lens does not change image* scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER	**$169.50**
2'' EASY-GUIDER (Mamiya 645)	**$199.50**
2'' Adapter for Pentax 6X7	**$129.00**
2'' Adapter for Hasselblad	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$235.00**

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply *thread it onto the rear cell, then attach all normal* accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	**$119.50**
UV/Dust Deal for Celestron C-8	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $59.50

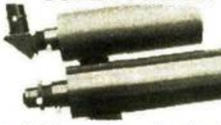
LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$59.50**
LUMICON 2'' Helical Focuser 1½'' high	**$65.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' **adapter** w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. *Eyepieces and/or star diagonal are extra.*

1¼'' 50mm Finderscope **$59.50**, right-angle	**$59.50**
1¼'' straight-thru 80mm SUPER-FINDER	**$169**
1¼'' right-angle 80mm SUPER-FINDER	**$179.50**
1¼'' right-angle version, w/star diagonal	**$209**
25mm Cross-hair 1¼'' eyepiece (12X)	**$39**
Large mounting rings for 80mm Finder	**$55**
1¼'' Star Diagonal **$39**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$52.44**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc.	**$26.00**
2'' adapter for C-80, C-100 *refractor*	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	***$39.50***
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension	**12.00**
2½'' long extension (holds 1¼'' filters)	**16.00**
4½'' long extension for 1¼'' eyepieces	**$25.00**
3'' long extension for 2'' eyepieces*	**$26.00**
2'' long extension for 2'' eyepieces*	**$26.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$20.00**
2''/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

Barred Spiral Galaxy M-83 in Hydra. 60 minute photo by Tony Hallas and Daphne Mount using a LUMICON 14" f/7 Schmidt-Cassegrain and LUMICON Giant Easy-Guider with hypered 2415 film. *If it wasn't for your accessories, these astrophotos wouldn't have been possible,* said Tony. Use the LUMICON Deep-Sky Filter to see the spiral structure in M-83 visually.

"I'd Pick The TELE VUE™"

40mm Wide-Field Test, "Astronomy," Aug. 1990, p. 90

Genesis 4" f/5 4 element fluorite	$1885
Pronto 70mm f/6.4 apochromat w/2" diagonal	$825
Pronto 70mm f/6.4 w/45° erecting prism	$725
Renaissance-SDF 4" f/5.4, brass	$2095
Gibralter mount with ash wood tripod	$495
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	$79
1.8x or 2.5x Tele Vue Barlow Lens	$89
2" Giant Barlow - 2x	$169
32mm Plossl, widest true field in 1¼"	$109
55mm 2" Plossl, widest possible field	$219
15mm Wide-Field, 1¼" eyepiece, 65°	$135
19mm Wide-Field, 1¼" eyepiece, 65°	$145
24mm Wide-Field, "Rich-Field!" 65°	$169
32mm Wide-Field, 2" eyepiece, 65°	$239
40mm Wide-Field, "Rich-Field!" 65°	$299
4.8mm Nagler, 82° field, 1¼" eyepiece	$149
7mm Nagler, 1¼" eyepiece, 82° field	$189
9mm Nagler, 82° field, 1¼" or 2"	$219
13mm Nagler, 82° field, 1¼" or 2"	$249
12mm Nagler, Type II, 82°, 1¼"/2"	$249
16mm Nagler, Type II, 82°, 1¼"/2"	$289
20mm Nagler, Type II, 82°, 2" only	$340
1¼" Paracorr Visual Coma Corrector	$159
2" Paracorr Visual Coma Corrector	$249
NEW! 15mm Panoptic 1¼", 68° field	$199
NEW! 22mm Panoptic 1¼"/2", 68°	$249
NEW! 27mm Panoptic 2", 68° field	$299
NEW! 35mm Panoptic 2", 68° field	$325

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$159.00**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

AMAZING OIII FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."*
Astronomy, Feb. 1991

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	$59.50
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	$79.50
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	$119.50
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$119.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	$299.50
2" Rear Cell Filter, fits SCT's ... Deep-Sky, **$119.50** UHC, O-III, H-Beta,	$199.50
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	$199.50
Set of both premium **DEEP-SKY** and **UHC Filters** (Save 11%) ... 1¼" **$159.50**; 48mm	$279.50
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. 1¼" ... **$99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines ... 1¼" **$99.50, 48mm**	$199.50
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	$6.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$16.00
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$20.00

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$59.00	$49.00
52, 55, 58, 62mm	$69.00	$59.00
67, 72, 77mm	$79.00	$69.00
82mm	$89.00	N/A

Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

LUMICON®

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FAX (6 PM-9 AM PST) (510) 447-9589
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All foreign orders add 8% ($10 minimum)
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Prices subject to change w/o notice.
Hrs: M-F 9 am - 5 pm, Sat. 11 am - 3 pm

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.
U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$189.50**
3X Relay Diagonal (see photo)	**$89.50**
Illuminated reticle eyepiece, pulsed	**$109.50**

Guider for Hasselblad **$350**, Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$249.00**
Adapter for Hasselblad **$198,** Mamiya 645 **$98**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ..... **add $99.95**
Adapter for Hasselblad **$295,** Mamiya 645**$149**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**

3. **LUMICON Digital Drive Corrector . $249**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 30Hz/90Hz variable output controls telescope drive. 60Hz digital reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Dec. reverse switch for Newtonians.

Declination motor (state telescope) ... **$109**
Variable dec. speed drive w/built-in 5AH battery **$299**

Kodak
SR1600
Scotch
1000
NEW
SRV3200

HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Ektar 1000 fast, fine grain	24	**$12.95**
Fuji HG400 fine grain color neg.	12	**$13.95**
3M 1000, fastest slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

SKY ALMANAC

May 1994

Annular Solar Eclipse Cuts Path Across United States

On May 10 observers in a path from Baja California, Mexico, to Maritime Canada will see an annular eclipse of the Sun. Because the Moon is relatively distant at the time, it will not fully cover the Sun, leaving a ring or "annulus" of sunlight. Because of this, proper filters must be used to view the eclipse safely. Coverage of this eclipse appears both in Sky Almanac and in "May's Ring of Fire," on page 92.

Partial Lunar Eclipse Occurs on May 24/25

This month's second eclipse, visible from the United States as well as Europe, sees the Moon passing into Earth's shadow, creating a partial lunar eclipse. The eclipse begins at 9:18 p.m. EDT on May 24 and progresses for three hours. At maximum coverage about one-quarter of the Moon will darken.

Comet Tempel 1 Swings Past the Virgo Cluster

Mimicking an elliptical galaxy in overall appearance, periodic Comet Tempel 1 will drop south in declination this month as it skirts the eastern edge of the Virgo Cluster of galaxies. The 9th-magnitude fuzzball will pass close-by several fainter galaxies, making a challenging sport out of identifying the comet. The finder chart on page 85 will make the task possible.

Comet Shoemaker-Levy 9 Approaches Jupiter

In mid-July Comet Shoemaker-Levy 9 will collide with Jupiter. This month the two are slowly converging as they glide across Libra and into Virgo. You may spot the elusive, 14th-magnitude comet by first finding Jupiter and then offsetting in right ascension and declination (see table on page 84). Over the coming few weeks the two will draw closer yet in the sky as the comet crash looms.

CALENDAR OF EVENTS

1 The Moon passes 4° north of Neptune, 2 a.m. EDT
The Moon passes 5° north of Uranus, 8 a.m. EDT

2 Last Quarter Moon is at 10:32 a.m. EDT

4 Eta Aquarid meteor shower peaks at 11 p.m. EDT

8 The Moon passes 4° north of Mars, midnight EDT
The Moon is at apogee (252,539 miles from Earth), 10 p.m. EDT

10 New Moon is at 1:07 p.m. EDT; annular eclipse

13 The Moon passes 4° south of Venus, 2 a.m. EDT

17 Pluto is at opposition, 4 p.m. EDT

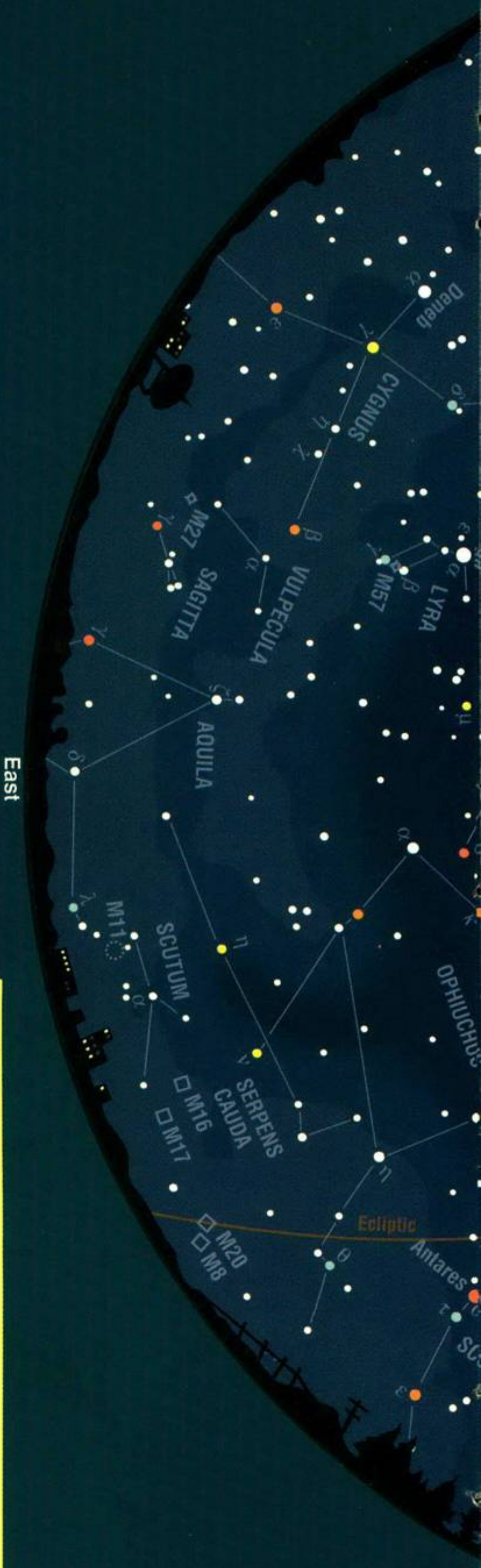
18 First Quarter Moon is at 8:50 a.m. EDT

23 The Moon passes 3° south of Jupiter, 7 a.m. EDT
The Moon is at perigee (222,957 miles from Earth), 11 p.m. EDT

24 Full Moon is at 11:30 p.m. EDT; partial lunar eclipse

28 The Moon passes 4° north of Neptune, 10 a.m. EDT
The Moon passes 5° north of Uranus, 4 p.m. EDT

30 Mercury reaches greatest eastern elongation (23°), 3 a.m. EDT



1994 SOFTWARE BUYER'S GUIDE

From the Editors of ASTRONOMY Magazine

A SUPPLEMENT TO ASTRONOMY
MAGAZINE

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Orion Nebula image by National
Optical Astronomy Observatories

SOFTWARE FOR DESKTOP MARS EXPLORATION!

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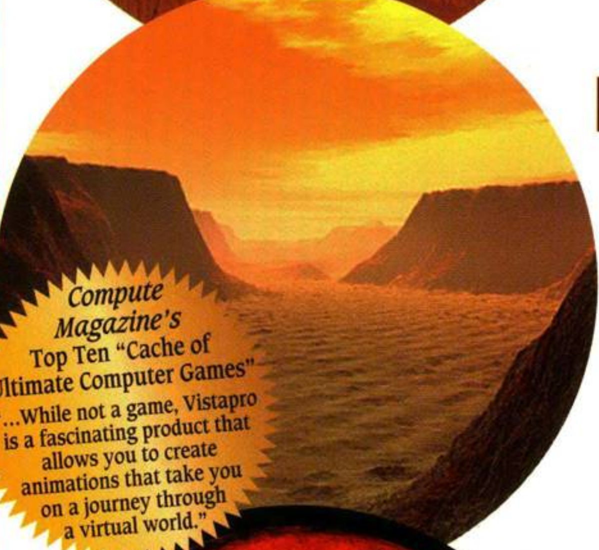

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Vistapro is based on real-world data obtained from NASA and the U.S. Geological Survey, and allows you to recreate, animate and explore stunningly beautiful landscapes. Vistapro CD includes over 200 MB of Mars data (almost the entire planet); Makepath Flight Director and Vistamorph (for advanced animation techniques); examples and more!

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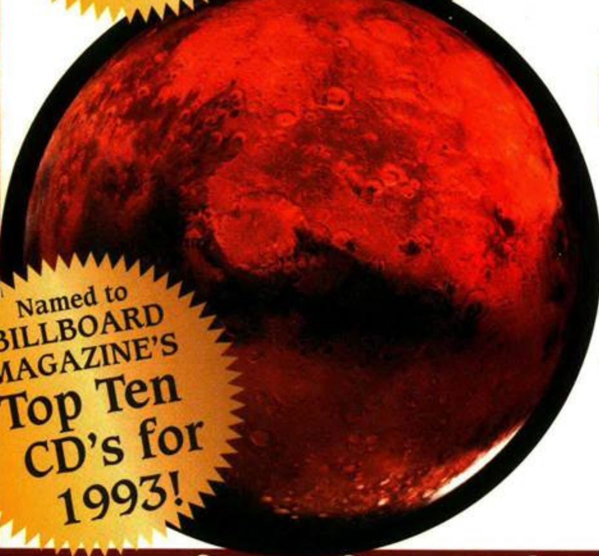

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How to Build Your Own Observatory, Third Edition
How to make everything from a simple wind shelter to a classic white dome to house your telescope. Includes numerous photos and diagrams with construction techniques. From *Telescope Making* magazine. 8½ x 10½, 97 pgs., 164 b&w photos, 25 illus., sftbd. #18004 .... **$14.95**

Quick Reference Guide to ASTRONOMY Magazine 1973-1990
Quickly find articles, subjects and individual objects by categories that include astronomical objects, photography, equipment, observing, and photos. Fast, easy desk reference. Includes update for 1991. By Jack Hobart. 8¼ x 11, 75 pgs., sftbd. #30226 .... **$8.00**

How to Make a Telescope, 2nd Edition
The classic reference book describes how to grind, polish and test optics and build a Newtonian or Cassegrain telescope. Many useful appendices. By Jean Texereau. 6¼ x 9½, 424 pgs., 72 b&w photos, 100 illus., hrdbd. #30048 .... **$19.95**

Celestial Delights
A beginning viewer's guide to the best sky shows from now through the year 2001. Explains when, where, and how to view lunar and solar eclipses, planetary arrangements, meteor showers, and other interesting events visible to the naked eye. Also includes the latest planetary information and photos from NASA, comprehensive sky maps, and hints on photographing the night sky. By Francis Reddy and Greg Walz-Chojnacki. 7 x 9, 266 pgs., sftbd. #30266 .... **$16.95**

Sky Atlas 2000.0
The standard of excellence in a one-volume star atlas. Twenty-six fold-out color charts show 43,000 stars down to magnitude 8.0 and more than 2,500 deep-sky objects. By Wil Tirion. 11 x 16, 385 pgs., 26 charts, sftbd. #30022 .... **$44.95**

ASTRONOMY
ATLAS OF THE MOON
How to Build Your Own Observatory
STAR NAMES
Their Lore and Meaning
WIL TIRION
skyAtlas
2000.0
A CONCISE DICTIONARY OF ASTRONOMY
OBSERVING HANDBOOK AND CATALOGUE OF DEEP-SKY OBJECTS

Star Names: Their Lore and Meaning
The classic book on star lore which explains the origins of star names in Chinese, Arabic, Hellenic, and Greco-Roman cultures. By Richard Hinkley Allen. 5½ x 8½, 563 pgs., sftbd. #30003 .... **$8.95**

Sky Catalogue 2000.0 V1: Stars to Magnitude 8.0
An observer's companion on stellar data, containing basic information such as positions, magnitudes, spectral types, B-V colors, absolute magnitudes, distances and equivalent names. By Roger Sinnott and Alan Hirshfeld. 9 x 12, 700 pgs., 18+ b&w photos, 350+ illus., sftbd. #30023 .... **$39.95**

Uranometria 2000.0 V1: The Northern Hemisphere to -6° declination
The quintessential star atlas for amateur sky observers. Contains 259 charts which, together with those in Uranometria 2000.0 Volume II, depict 332,000 stars down to magnitude 9.5 and 10,300 deep-sky objects. By Tirion, Rappaport, Lovi. 9¼ x 12¼, 565 pgs. (Vol. 1&2), 500 illus. (Vol. 1&2), hrdbd. #30156 .... **$39.95**

Uranometria 2000.0 V2: The Southern Hemisphere to +6°
#30157 .... **$39.95**

The Deep Sky Field Guide to Uranometria 2000.0
All the pertinent data for Uranometria 2000.0's deep-sky objects in an easy-to-use format. A complete list of errata and addenda for each map as of November 1992 is included. By Murray Cragin, James Lucyk and Barry Rappaport. 9 x 12, 408 pgs., hrdbd. #30263 .... **$49.95**

Telescope Optics: Evaluation and Design
A guide to buying or producing your own telescope optics, providing background on lenses and mirrors, telescopic aberrations, and types of optical systems. By H. Rutten & M. Van Venrooij, 6¼ x 9¼, 384 pgs., hrdbd. #30175 .... **$24.95**

The Hubble Atlas of Galaxies
Based on Edwin Hubble's classification scheme for galaxies, astronomer Allan Sandage provides photographs and analysis of 176 galaxies. By Allan Sandage. 15 x 11½, 51 pgs., 176 b&w photos, hrdbd. #30231 .... **$39.95**

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How to speak astronomy. Contains more than 2,400 definitions of terms and concepts important to understanding astronomy as a science, from AAO (Anglo-Australian Observatory) to ZZ Ceti star. By Jacqueline Mitton. 5¼ x 8, 423 pgs., 42 illus., hrdbd. #30257 .... **$24.95**

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The best material from 21 years of the *Maksutov Circulars*, the influential newsletter for precision amateur telescope makers. By Allan Mackintosh. 6 x 9, 320 pgs., 42 b&w photos, 450 illus. (Vol. 1&2), sftbd. #30142 .... **$19.95**

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Observing Handbook and Catalogue of Deep-Sky Objects
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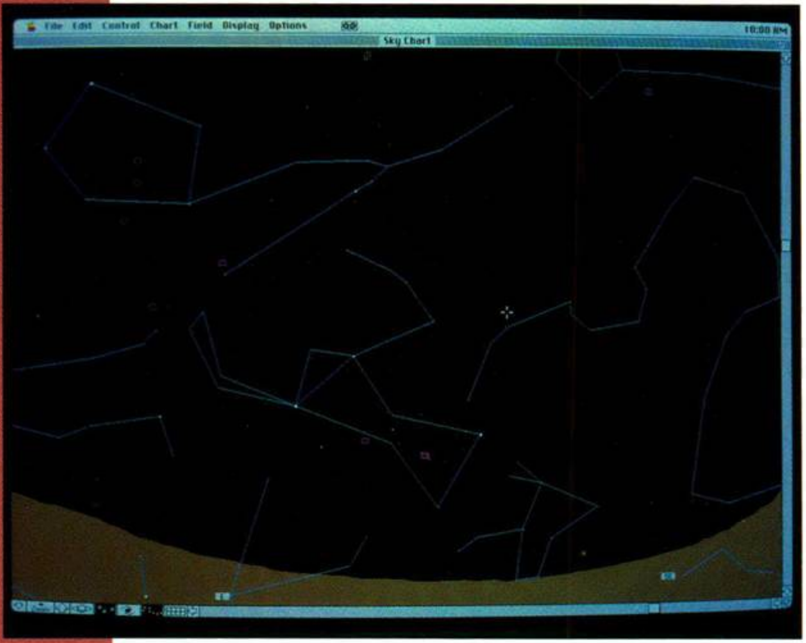


Planetarium-type program: Voyager II by Carina Software

If you haven't checked out the universe of astronomy available on computers, you don't know what you're missing.

Ten years ago few astronomical programs existed. But today you'll find a dizzying collection of excellent ones to choose from. This guide will tell you about some of them and help you choose the software you want. And it will introduce you to electronic bulletin boards (see "Electronic Connections") and CD-ROMs used for data and image storage (see "Megastorage").

The heart of the computer universe lies in software that lets you explore the richness of the night sky, plan and record your observations, and enhance images. Many of the programs speak to the needs of observers, but armchair astronomers needn't feel left out. A growing number of programs animate celestial events or explore the nature of astronomical objects.

Observers can do many of the tasks that

GLOSSARY OF COMPUTER TERMS

COMPUTER HARDWARE

8086, 80286, 80386, 80486: Manufacturers' numbers for the computer chip that forms the brain of your computer.

math coprocessor: An extra circuit chip that quickly performs complex math functions that the computer chip does at a much slower rate.

CD-ROM: Compact disk, read only memory — a disk like an audio CD that can hold hundreds of megabytes of data from which you can read but not write.

RAM: Random access memory — the place where your computer stores programs and data.

byte: A basic unit of computer memory and disk space that stores one character or numeral.

kilobyte (KB): 1,024 bytes, or characters, of computer memory or disk storage.

megabyte (MB): 1,024 kilobytes, or roughly a million characters.

gigabyte (GB): 1,024 megabytes, or roughly a billion characters.

IMAGE FILE FORMATS

BMP: Bitmap image, commonly used in Windows programs.

FITS: Flexible image transport system, commonly used for CCD images.

GIF: Graphics interchange format, developed by CompuServe and commonly used by bulletin boards.

JPEG: Joint Photographic Experts Group, commonly used to compress image files so they use less room on disks.

Photo CD: Kodak's CD, used to store digitally scanned photographs.

PICT: Picture format, used by Macintosh programs.

PIX: Picture format, used by some PC screen capture programs.

RAW: An image file without any special formatting information, sometimes used by CCD cameras.

TIFF: Tag image file format, used by many graphics and image-processing programs for its flexibility.

NETWORK TERMS

baud: Number of bits (8 bits = 1 byte) a modem sends every second.

bulletin board: A computer system you can link with using a modem; it contains programs, messages, and text files.

e-mail: A system that sends messages electronically via a computer network.

freeware: A program the developer shares at no cost.

modem: A device that links your computer to another via a phone line.

shareware: A program you can try for a limited period — if you like it, you pay the developer a fee, which may entitle you to upgrades or a more powerful program.

VIDEO DISPLAYS

adaptor: A card or chip inside your computer that produces the screen display

CGA: Color graphics adaptor, displays up to 640 by 200 elements on your monitor and up to 4 colors.

EGA: Enhanced graphics adaptor, displays up to 640 by 350 elements on your monitor and up to 16 colors.

VGA: Video graphics array, displays up to 640 by 480 elements on your monitor and up to 256 colors.

Super VGA: A better-than-VGA adaptor that displays up to 1,024 by 768 elements and thousands of colors.

computers perform — making finder charts, plotting the position of a new comet, and entering notes about star clusters from last night's observing session. But who wants to spend hours redrawing charts by hand or computing tonight's position of an asteroid using a calculator or a pencil and a piece of paper? Computers can save you time — and drudgery —and let you spend more time at the telescope. In fact, you can let your computer control your telescope while you observe from the comfort of your home.

But computers do more than save labor. They also let you explore the universe in ways you could only imagine just ten years ago. Recently developed programs let you tour the Local Group of galaxies, watch solar and lunar eclipses, hike the surface of Mars, enhance images taken with film and CCD cameras, build binary star systems, and much more.

Selecting software involves many personal choices so we can't tell you which programs are best for you. The tables in this guide will help you select DOS-, Windows-, and Mac-based programs and will tell you if a program requires special hardware such as a math coprocessor, CD-ROM drive, or a particular display. You'll find a glossary (opposite) to decipher the morass of acronyms that computer buffs use.

Astronomical software falls into several main categories: observing programs, image processing programs, and special-purpose programs. **Observing programs** contain four subgroups: planetarium-type programs, sky simulators, deep-sky-observing programs, and observatory programs. (See "The Electronic Sky.")

Planetarium-type programs show the positions of the stars and planets and let you display constellation figures. Most of these programs also display a number of deep-sky objects such as star clusters and galaxies. Some will also plot the positions of asteroids and comets and let you find past and future positions of planets.

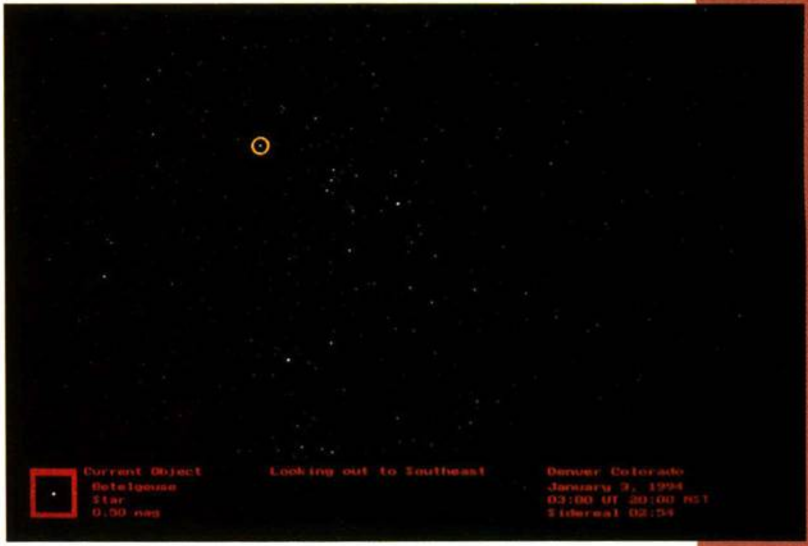
Sky simulators don't plot constellation lines or coordinate grids as planetarium-type programs do, but they outdo these programs at showing how the sky really appears at night. They add twilight glow and other features to mimic the sky.

Deep-sky observing programs excel at showing the positions of numerous galaxies, nebulae, and star clusters. These programs also show the positions of stars, sometimes plotting fainter stars than planetarium-type programs. They also permit you to print finder charts for use at your telescope.

Observatory programs let you operate your telescope from your computer. In most cases the developers have combined a planetarium-type program with a telescope controller. So finding an object becomes as simple as moving a cursor to it on a sky map displayed on the monitor and clicking on a mouse to move the scope.

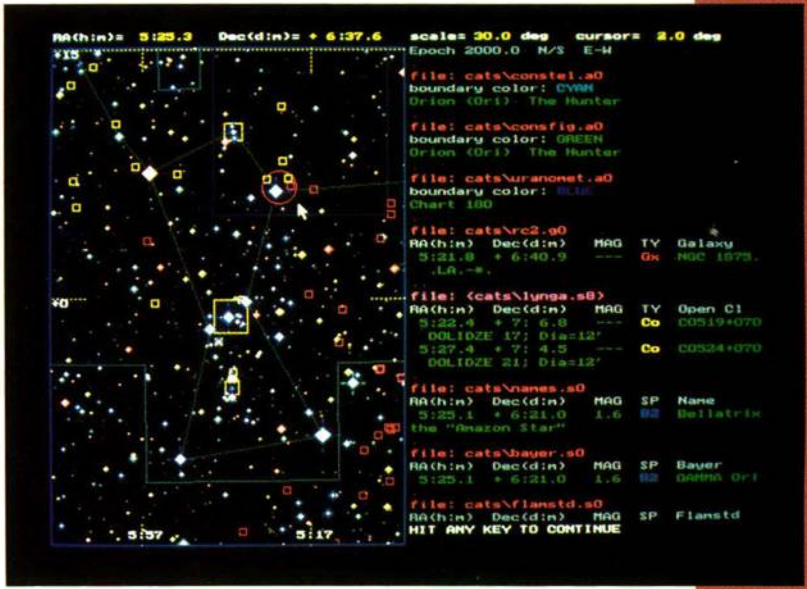
Image-processing programs allow you to enhance images with a variety of techniques that mimic what photographers perform in their darkrooms. (See "Image Processing.")

Special-purpose programs permit you to study binary stars, plot the path of an eclipse, explore telescope optics, investigate the orbits of stars and planets, view Mars from its surface, make a planet, keep logs of your observing sessions, and much, much more. (See "Expanding Your Horizons.")



```
Current Object      Looking out to Southeast      Denver Colorado
 Betelgeuse                                        January 3, 1994
 Star                                              03:00 UT 20:00 MST
 0.50 mag                                          Sidereal 02:54
```

Sky simulator: PC- Sky by CapellaSoft



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                                         boundary color: CYAN
                                         Orion (Ori)  The Hunter

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                                         boundary color: GREEN
                                         Orion (Ori)  The Hunter

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                                         Chart 180

                                         file: cats\rc2.g0
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                                           .LA.-*.

                                         file: <cats\lynga.s8>
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                                          5:22.4  + 7: 6.8    ---  Co  C0519+070
                                           DOLIDZE 17; Dia=12'
                                          5:27.4  + 7: 4.5    ---  Co  C0524+070
                                           DOLIDZE 21; Dia=12'

                                         file: cats\names.s0
                                         RA(h:m)  Dec(d:m)    MAG  SP  Name
                                          5:25.1  + 6:21.0    1.6  B2  Bellatrix
                                         the "Amazon Star"

                                         file: cats\bayer.s0
                                         RA(h:m)  Dec(d:m)    MAG  SP  Bayer
                                          5:25.1  + 6:21.0    1.6  B2  GAMMA Ori

                                         file: cats\flamstd.s0
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                                         HIT ANY KEY TO CONTINUE
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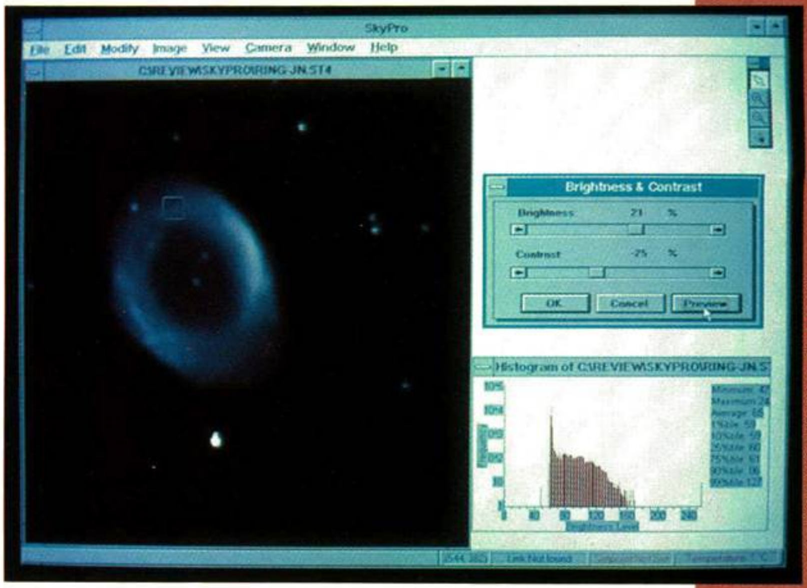
Deep-sky observing program: HyperSky II by Willmann-Bell



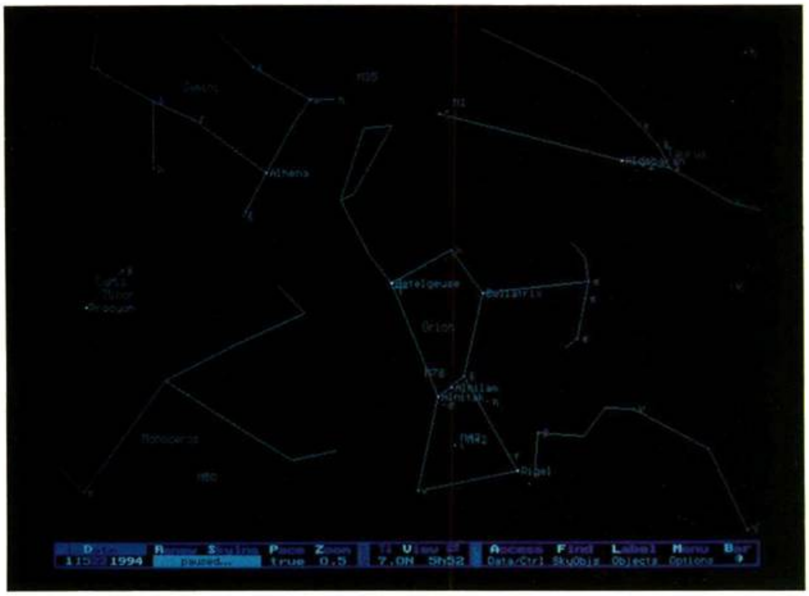
SkyPro
File Edit Modify Image View Camera Window Help
C:\REVIEW\SKYPRO\RING-JN.ST4
Brightness & Contrast
OK
Cancel
Preview
Histogram of C:\REVIEW\SKYPRO\RING-JN.S
Brightness Level
0
40
80
120
160
200
240
Link Not found
Temperature

Brightness 21 %

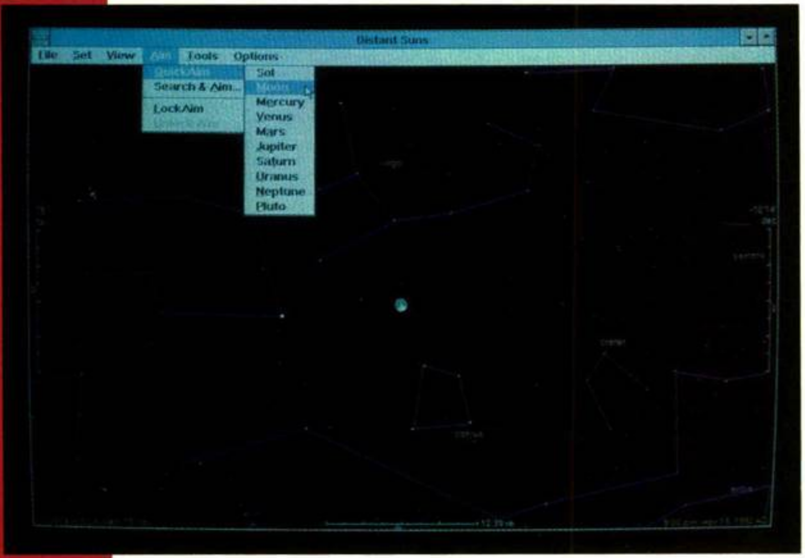
Contrast -25 %

Image-processing software: SkyPro by Software Bisque

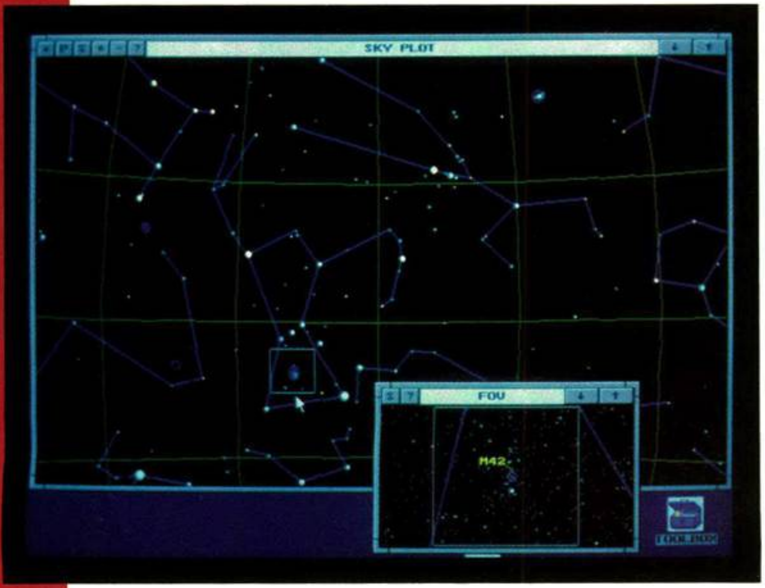
ASTRONOMY: All screen images by Darla Evans



Dance of the Planets by ARC Science Simulations



Distant Suns for Windows by Virtual Reality



StarGaze by C.E.B. Metasystems

Planetarium-type programs, sky simulators, deep-sky software, and observatory programs all open a window to the universe for personal computer users. These observing programs let you find where the planets are each night, determine the phase of the Moon, locate deep-sky objects such as nebulae and galaxies, plan an observing session, or create a finder chart for use at the telescope. Armchair explorers also use these programs to find the position of a planet 1,000 years ago or 1,000 years in the future, look at the distribution of star clusters throughout our Galaxy, animate the motions of planets through the sky, and view the planets from different positions within the solar system. Which one you need depends on the observing you do or the phenomena you want to explore.

Choices were easier several years ago because few programs existed, especially if you used Windows or a Macintosh. But now many fine programs are available for different types of computers and their various operating systems. When considering the purchase of a program, you should note if it requires a special video display, a math coprocessor, or extraordinary hard-disk space. Most Windows-based programs still work in 3.0 but a few require 3.1. A few Mac programs now require System 7.X. More and more programs offer CD-ROMs as an option to extend their database or for loading the program and database.

One factor in deciding between observing programs is the extent of their databases. Traditionally these programs have used the *Bright Star Catalog* to show the positions and brightnesses of over 9,100 stars brighter than about magnitude 6.5 — or a portion of this catalog. Others used the 250,000 stars of the Smithsonian Astrophysical Observatory (SAO) star catalog, extending the brightness limit to 8th magnitude. Now many of the programs use the Hubble *Guide Star Catalog* with its over 15 million stars or provide this catalog as an option. In either case you need a CD-ROM drive to use this catalog.

The position and brightness of galaxies, nebulae, and star clusters form a program's deep-sky object database. Some of the inexpensive programs use only Charles Messier's catalog of 110 objects. Most of the programs use part or all of the *New General Catalogue* that lists almost 8,000 objects. A few deep-sky observing programs add other catalogs to this basic database, letting you find fainter nebulae, galaxies, and star clusters. These extra catalogs also let you customize your observing database so you can concentrate on your interest in double stars, supernovae remnants, open star clusters, globular star clusters, or other types of objects.

All of the planetarium-type programs will display the planets, although not all of the deep-sky programs do. So a planetarium-type program can still be a useful tool to deep-sky observers, especially for finding the phase and location of the Moon. Some of these programs show the four largest satellites of Jupiter and a few also feature other planetary satellites. Many of the observing programs now add comets and asteroids to their database or let you add a set of elements that describe an object's orbit so the program can calculate a comet's or asteroid's position for any time. This latter method is superior because it lets you follow the rapidly changing orbit of a comet such as Shoemaker-Levy 9, which is nearing its collision with Jupiter. Updated orbital elements for comets and asteroids are often available on astronomical bulletin boards or on-line computer services (see "Electronic Connections").

Some of the programs also allow you to display images of the planets and some deep-sky objects, or let you add your own digital images to the image file. This feature is a great eye-catcher for Astronomy Day programs, club events, or school presentations. And, if you add your own images, you can keep track of your favorite astronomical photos in a convenient way.

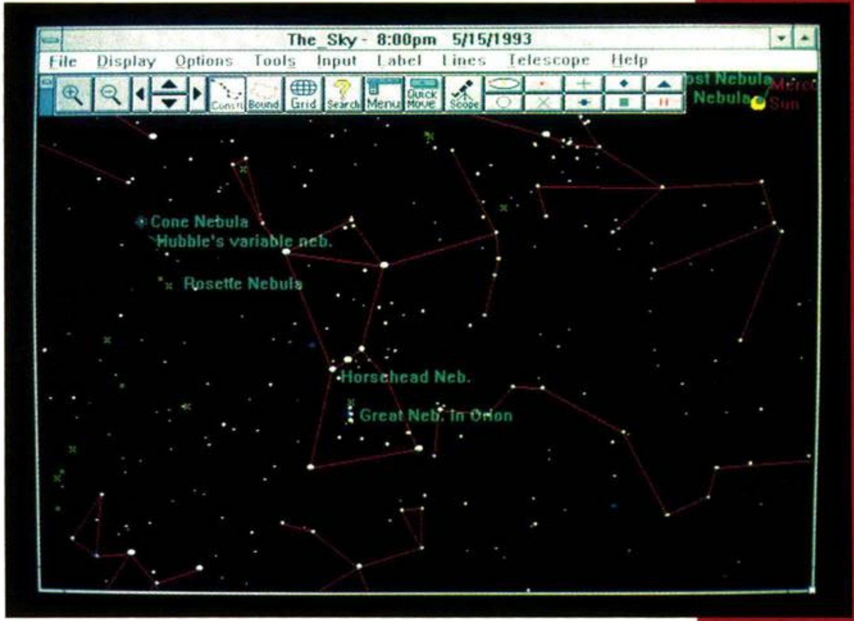
If you want to explore the skies more than 100 years into the past or future, you need a program that will calculate precession, the slow wobble of Earth's axis over 26,000 years. Exploring ancient skies is one way to get a better feeling for how our ancestors viewed the universe: It didn't always look the way we see it today. Be warned that not all programs use orbital calculation methods precise enough to compute planetary positions far into the past or future, so check the program's accuracy if you wish to do this.

Most programs let you animate the motions of solar system objects so you can watch the path of Jupiter during the upcoming opposition or view a solar eclipse. This eclipse feature shows only the disappearance of the Sun as the Moon passes in front of it. You need another program to plot the eclipse path across Earth's surface (see "Expanding Your Horizons"). You can also use the animation feature to look for conjunctions (groupings of the planets in the sky) and possible occultations, events that occur when the Moon passes in front of a star.

For deep-sky observing, you will want the program to be able to print a finder chart that you can use at the telescope. Be sure that the chart printing routine works with your printer. Check that you can turn the display of different classes of deep-sky objects on and off to make customizing the chart easier. Some programs also let you attach labels to objects on the chart or even keep observing notes for each object.

Another useful feature for deep-sky programs is a reticle or circle displayed on the screen that shows the size of your finderscope's field of view or that of your eyepiece. Some of these programs show the actual size of an object, not just a symbol showing its position. And one program even shows the orientation of a galaxy in the sky.

Have a computerized scope? Now you can run your scope from your planetarium-type or observatory program. All you have to do is find the object you want to look at on your screen. A click of a mouse button will send the telescope on its way to finding the object. Many of the programs will control Meade's LX-200 series of telescopes and some will also control a CCD camera. If you have another scope, check with the software developer to see if their program will work with your model.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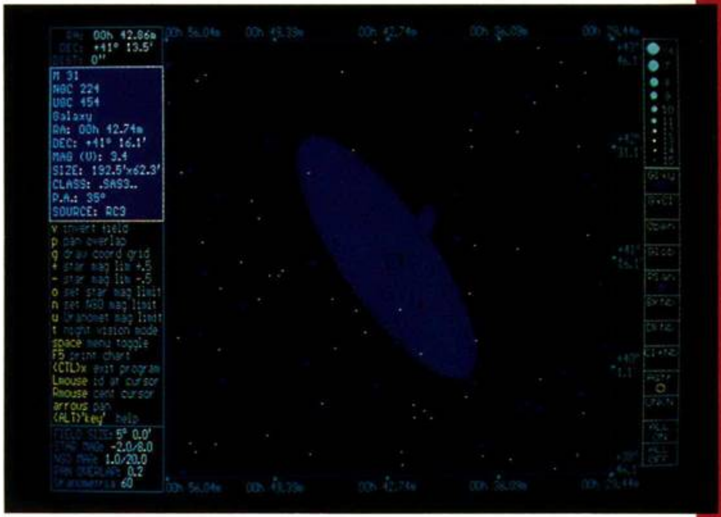
Hubble's variable neb.
Rosette Nebula
Horsehead Neb.
Great Neb. in Orion
Nebula
Sun

TheSky for Windows by Software Bisque



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DEC: +41° 13.5'
0"
M 31
NGC 224
UGC 454
Galaxy
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DEC: +41° 16.1'
MAG (V): 3.4
SIZE: 192.5'x62.3'
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P.A.: 35°
SOURCE: RC3
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v invert field
p pan overlap
g draw coord grid
+ star mag lim +.5
- star mag lim -.5
o set star mag limit
n set NGO mag limit
space menu toggle
F5 print chart
(CTL)x exit program
Lmouse id at cursor
Rmouse cent cursor
arrows pan
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1.0/20.0
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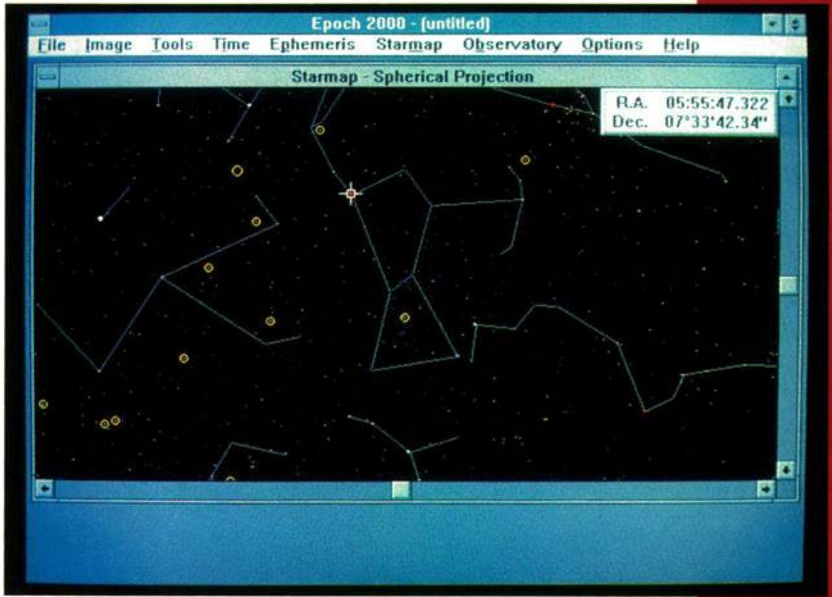
MegaStar by E.L.B. Software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File Image Tools Time Ephemeris Starmap Observatory Options Help
Starmap - Spherical Projection
R.A. 05:55:47.322
Dec. 07°33'42.34"

Epoch 2000 by Farpoint Research

PLANETARIUM-TYPE PROGRAMS

Program Name	Version	Developer	Price	Comp	System	CD-ROM	H. Drive	Mem	Display	# Stars	# Objects	Opt DB	Rev.
Big Blue Skies		Andromeda Soft.	S	PC	DOS		—	—	VGA	1,500	—	3,200 stars	
Dance of the Planets	2.7	ARC Sci. Sim.	$195	PC	DOS		yes	640KB	EGA	9,100	1,400	yes	5/92
Dance of the Planets	Q.E.D.	ARC Sci. Sim.	$145	PC	DOS		yes	640KB	VGA	9,100	1,400	yes	
Distant Suns	4.2	Virtual Reality	$ 99.95	Amiga			—	1MB	—	—	2,000	yes	
Distant Suns	2.0	Virtual Reality	$ 99.95	Mac	6 or 7		3.5MB	2MB	—	10,000	2,000		3/94
Distant Suns	2.0	Virtual Reality	$149.95	Mac	6 or 7	X	3.5MB	2MB	—	15 million	—		3/94
Distant Suns	2.0	Virtual Reality	$ 69.95	PC (386)	Win 3.1		5.5MB	2MB	VGA	9,100	450		4/92
Distant Suns	2.0	Virtual Reality	$149.95	PC (386)	Win 3.1	X	5.5MB	2MB	VGA	15 million	—		
Earth Centered Universe	1.5	Nova Astronomics	$ 35	PC (386)	Win		—	700KB	EGA	9,100	10,000	yes	
Expert Astronomer		Expert Software	$ 49.95	Mac	6.0.4		1.3MB	2MB	—	9,100	110		6/93
Expert Astronomer		Expert Software	$ 14.95	PC	DOS		no	512KB	CGA	9,100	110		12/92
Expert Astronomer		Expert Software	$ 14.95	PC	Win 3.1		yes	2MB	VGA	9,100	110		
Genesis	3.0	Lewis-Michaels Eng.	$ 69.95	PC (286)	DOS		15MB	—	CGA	259,000	7,840	yes	
LodeStar	2.1	Zephyr Services	$ 89.95	PC	DOS		—	—	CGA	9,000	110		
LodeStar Plus II		Zephyr Services	$149.95	PC	DOS		no	—	CGA	9,100	7,840	260,000 stars	
MacStronomy	2.0	Etlon Software	$ 60	Mac	6.0.4		yes	2MB	—	9,100	1,100	yes	
NightSky		Zephyr Services	$ 79.95	PC	DOS		—	—	CGA	9,000	—	50,000 stars	
PC SKY	1.1	CapellaSoft	$ 99	PC (286)	DOS		3.2MB	640KB	VGA	27,000	200		*8/93*
PLAstro		Zephyr Services	$ 99.95	PC	DOS		2.5MB	—	VGA	9,100	—		
Redshift		Maris Multimedia	$ 99	Mac		X	—	—	—	200,000	40,000		
Redshift		Maris Multimedia	$ 99	PC	Win	X	—	—	—	200,000	40,000		
Silicon Sky	6.2	Algol Software Works	$ 12	PC	DOS		—	—	EGA	—	—		
SkyGazer		Carina Software	$ 79.95	Mac			—	—	—	—	—		
Sky Globe	3.6	KlassM Software	$ 20	PC	DOS		no	640KB	CGA	29,000	110	yes	
StarGaze	2.1	C.E.B. Metasystems	$ 99.95	PC	DOS		6MB	640KB	EGA	500,000	9,000	yes	6/93
Superstar	4	picoScience	$149.95	PC	DOS		10MB	640KB	VGA	259,000	7,800	yes	
Superstar Pro	4	picoScience	$249.95	PC	DOS		10MB	640KB	VGA	259,000	7,800	yes	
The Cosmos	3.0	Mensys	$ 89.95	PC (386)	OS/2		4MB	—	VGA	9,100	150		
TheSky level II	2.0	Software Bisque	$129	PC	Win 3.1		5.5MB	1 MB	VGA	47,000	7,840		5&6/93
TheSky level III	2.0	Software Bisque	$199	PC	Win 3.1		12MB	1MB	VGA	259,000	13,000		
TheSky level II	5.0	Software Bisque	$ 99	PC	DOS		5.5MB	—	—	47,000	7,840		
TheSky level III	5.0	Software Bisque	$175	PC	DOS		12MB	—	—	259,000	13,000		
TheSky GSC	2.0	Software Bisque	$249	PC	Win 3.1	X	5MB	4MB	—	15 million	80,000		
Visible Universe	6	Parsec Software	—	PC	DOS		4MB	2MB	VGA	—	—	—	
Voyager II		Carina Software	$159.95	Mac	6 or 7	optional	1.5MB	2MB	—	50,000	4,200	yes	12/93
Voyager		Carina Software	$124.95	Amiga	—		—	1MB	—	9,100	1,200	yes	

DEEP-SKY PROGRAMS

Program Name	Version	Developer	Price	Comp	System	CD-ROM	H. Drive	Mem	Display	# Stars	# Objects	Opt DB	Rev.
Arizona Database	8.0	Arizona Database	$ 89.95	PC	DOS		13.5MB	—	—	—	60,000		
Dark Sky	1.0	Arizona Database	$129.95	PC	Win		—	—	—	259,000	61,000		
Deep Space 3D	3.0	David Chandler	$ 79	PC	DOS		2.5MB	512KB	CGA	19,600	13,000	yes	4/93
Guide	2.0	Project Pluto	$ 69	PC	DOS	X	yes	640KB	EGA	15 million	38,000		
HyperSky		Willmann-Bell	$ 49.95	PC	DOS	optional	2.3MB	500KB	CGA	46,000	5,500	yes	11/92
MegaStar	1.8	E.L.B. Software	$139	PC (286)	DOS	X	8-54MB	500KB	VGA	15 million	84,383		10/93
NGP		Gary Dean Williams	S	PC	DOS		2MB	512KB	—	—	8,164		1/92
Saguaro Database	6.0	Saguaro Astr. Club	$ 2	—	—		—	—	—	—	10,000		
SkyBase 2000.0	6.2	SkyBase Software	$ 64.95	PC	DOS		2MB	512KB	CGA	45,000	13,000	yes	

OBSERVATORY PROGRAMS

Program Name	Version	Developer	Price	Comp	System	CD-ROM	H. Drive	Mem	Display	# Stars	# Objects	Opt DB	Rev.
Epoch 2000	1.04	Farpoint Research	$329	PC	Win		5MB	640KB	EGA	45,000	13,000		9/93
Personal Observatory		CompuScope	$399	PC	DOS				VGA	—	—		
Remote Observing	1.0	Software Bisque	$299	PC	Win 3.1		yes	—	VGA	—	—		
Sky Pilot		Carina Software	—	Mac	—	—	—	—	—	—	—		
Stars & Scopes		So. Stars Software	$ 49	Mac	6.0.8		1MB	2MB	—		8,000		

An "S" in the "Price" column indicates a shareware program; if you like the program and want to keep it, you pay the developer an amount specified in the program's documentation. "Display" lists the minimum requirement. The program may support higher video modes. "Opt. DB" indicates whether optional databases are available to extend either the stellar or deep-sky databases. "Rev." indicates in which issue of ASTRONOMY a review of the software appeared.

No list of software can be complete since vendors introduce new software every day and multiple versions of some programs exist. No attempt was made to completely tabulate the multitude of shareware programs. We invite any software developer whose products are not contained in any of our tables to send a description of the software to Software Guide, ASTRONOMY Magazine, P.O. Box 1612, Waukesha, WI 53187. Review copies of programs are always appreciated.

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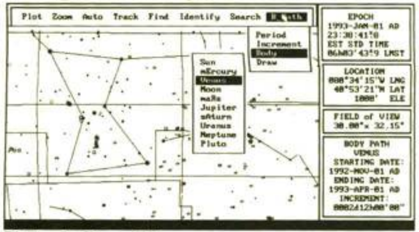

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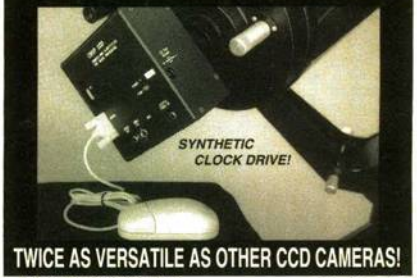

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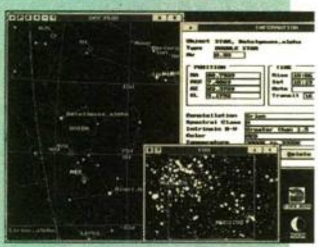

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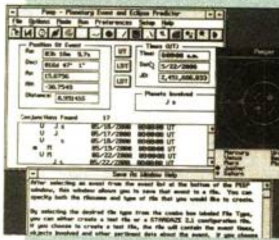

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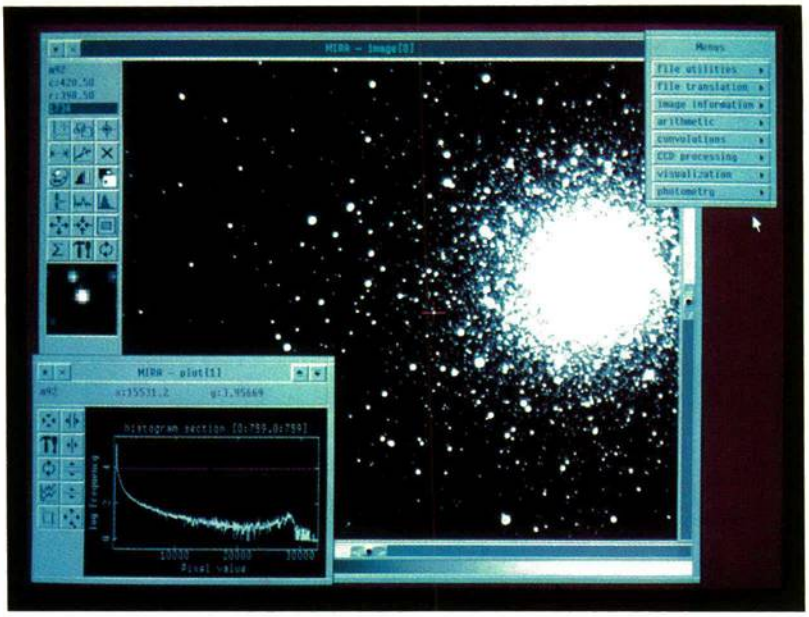
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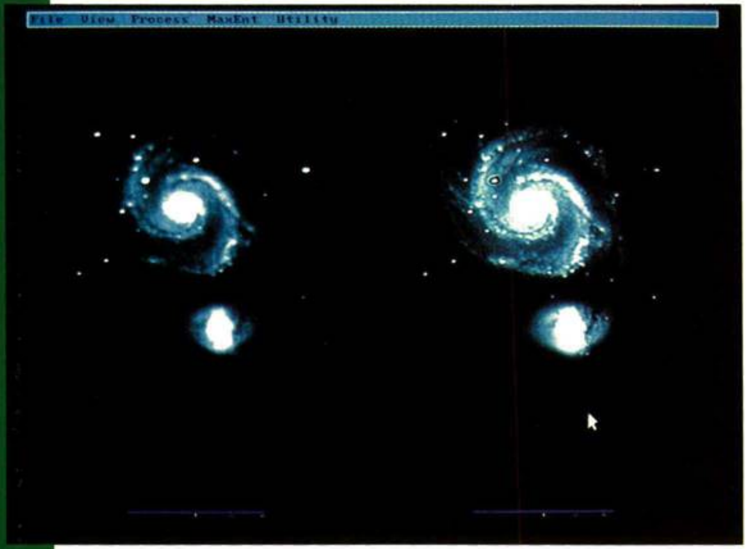
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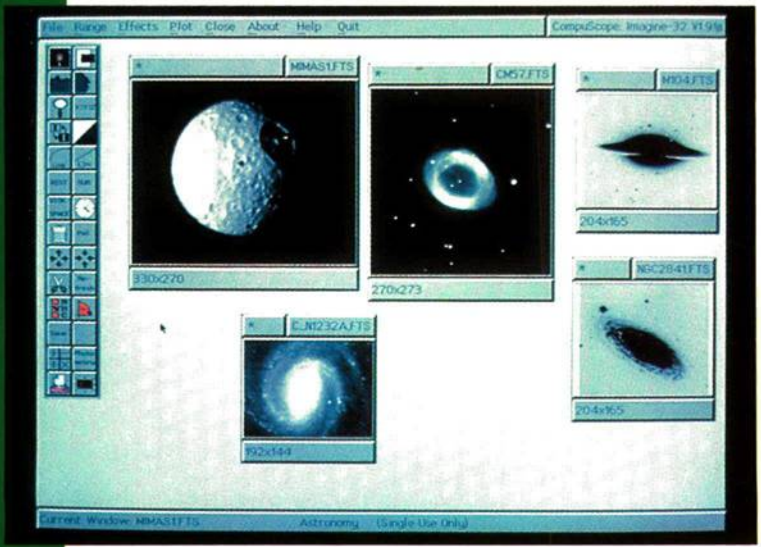
Hidden Image by Sehgal Corp.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About
Help
Quit
CompuScope: Imagine-32 V1.9g
MIMAS1.FTS
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CM57.FTS
270x273
M104.FTS
204x165
NGC2841.FTS
204x165
CJN1232A.FTS
192x144
Current Window: MIMAS1.FTS
Astronomy (Single Use Only)

Imagine-32 by CompuScope

Take an image, stretch its contrast, increase its brightness, sharpen its blurry features, and voilà, you have an enhanced image. You could have performed these same steps in a darkroom, but how many astrophotographers have one in this era of one-hour photo labs. Besides, who wants to mix smelly chemicals, worry about the temperature of the developer, and enlarge and dodge many prints until the features of a celestial object come out just right? The digital darkroom is faster, cleaner, more powerful, and a lot more fun.

Most people think about CCD images when they hear the words "image processing," but actually the digital darkroom can enhance any image. Graphics houses (see "Color Separations" in the Yellow Pages) can scan negatives, prints, or slides with a special reader that converts photos into digital files. Or you can have the local Kodak photo lab convert the images to a Photo CD (you need a CD-ROM drive to read these disks). And armchair astronomers who want to manipulate astronomical images but don't want to take them themselves, can also obtain many images on CD-ROM (see "Megastorage").

Whatever the source, the fun begins when you read an image into the computer's memory and start to enhance the faint features your eyes couldn't see. But which of the dozen-or-so available programs do you need to process images? Of course price can be a determining factor. If you have a Macintosh, the options are more limited than if you own an IBM PC-compatible computer. If you use Windows, you'll find a limited number of programs. Many of the program developers use DOS to reduce the systems requirements on the computer's memory.

Ask developers what video display cards their image-processing software supports. Some support only specific cards because of the requirements of their programs. Others will support almost any VGA or Super VGA card.

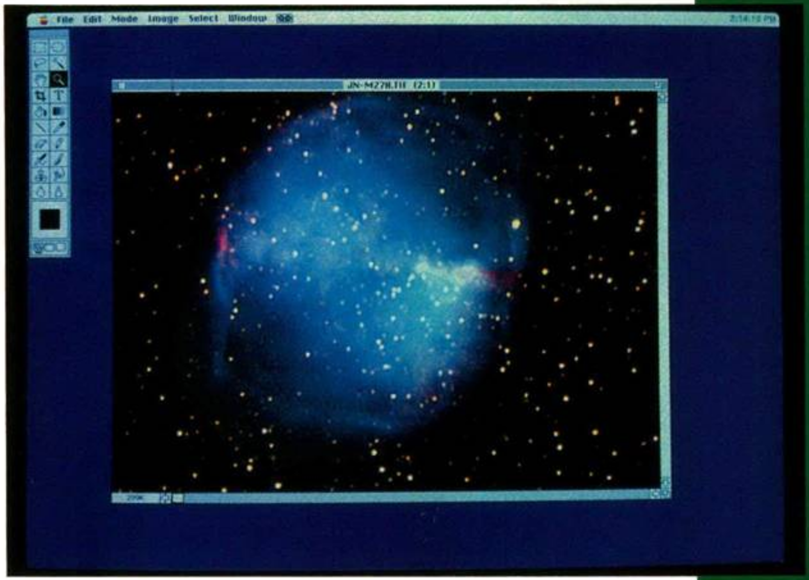
Another factor to consider is the image format you expect to use. Not all programs support all of the different image formats such as FITS or the ST6 CCD camera format. And not all programs support color images or the combination (called compositing) of three separate images taken through colored filters into one tricolor image. But more and more of the programs now support tricolor compositing and others will add this feature soon.

Most inexpensive programs let you perform many tasks of image processing, such as calibrating the image using flat field and bias frames and plotting histograms to show the brightness range of an image. Image calibration is an important step because it removes differences in sensitivity between pixels (picture elements, or each element in a CCD array). This step is akin to developing film. Enhancement steps like brightness stretching and sharpening are similar to printing in the darkroom.

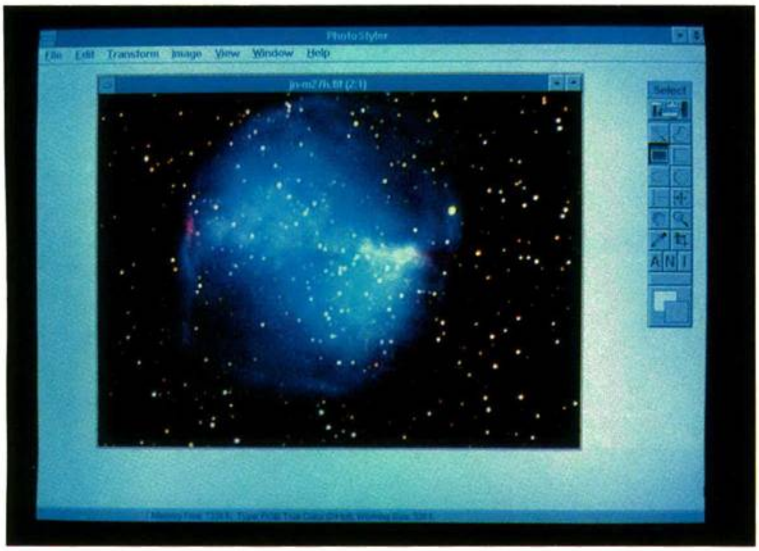
Inexpensive programs also provide many of the basic enhancement functions and filters. Filters are mathematical tools that act in predetermined ways on adjacent pixels. An example is the high-pass filter that suppresses large-scale variations in an image but maintains the small-scale (high frequency) details.

More expensive programs add additional features such as the ability to work on more than one image simultaneously and more powerful math functions like Fourier transforms or maximum entropy deconvolution. These latter functions allow you to remove the effects of bad seeing or poor guiding from images. Several programs also let you work with 32-bit data, which unleashes the full power of your 80386- or 80486-based computer.

Some of the programs are beginning to allow you to run a CCD camera directly from them so you don't need multiple programs to obtain and process images. All in all, this is probably the fastest changing area of the astronomical software market. Developers will release several major upgrades and at least one new program by the time this guide reaches your hands.

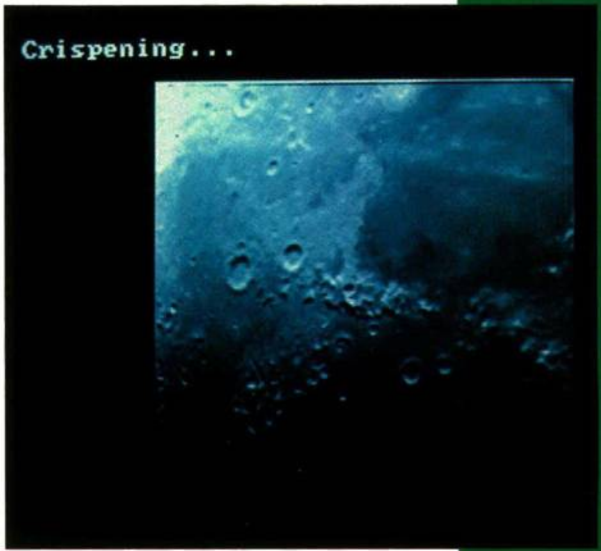


PhotoShop by Adobe Systems



M27 image by Jack Newton

PhotoStyler by Aldus Corp.



Crispening...

AstroIP from Willmann-Bell

IMAGE-PROCESSING PROGRAMS

Program Name	Version	Distributor	Price	Comp	Sys.	Notes
AstroIP	1	Willmann-Bell	$ 29.95	PC	DOS	general image processing
BatchPIX		Richard Berry	$ 29.95	PC	DOS	automatic processing of up to 255 images
ColorPIX		Richard Berry	$ 29.95	PC	DOS	color-image compositing from three filtered images
CB245PIX		Richard Berry	$ 49.95	PC	DOS	image processing for TC245 Cookbook camera
Hidden Image	1.3	Sehgal Corp.	$299	PC	DOS	maximum entropy deconvolution routine
Hidden Image 512	1.3	Sehgal Corp.	$399	PC	DOS	version for ST-6 cameras
Imagine-32	3.0	CompuScope	$299	PC	DOS	32-bit image processing
Imagine-32 Pro	3.0	CompuScope	$699	PC	DOS	version with extra filters and Fourier transforms
Improces	3.0	John Wagner	$ 25	PC	DOS	GIF and PCX image editor
Mira	2.06	Axiom Research	$595	PC	DOS	powerful 32-bit image processing
MultiPIX		Richard Berry	$ 39.95	PC	DOS	image compositing for TC211 cameras
PhotoShop	2.5	Adobe Systems	$895	MAC	6.0.7	image processing for publication
PhotoShop		Adobe Systems	—	PC	Win	general image processing
PhotoStyler	2.0	Aldus Corp.	$795	PC	Win	image processing for publication
SkyPro	1.1	Software Bisque	$199	PC	Win	general image processing

Accessing large databases has been a stumbling block for many programs until recently. Previously it took dozens of high-density diskettes to hold a stellar database like the Hubble *Guide Star Catalog*. Such a catalog took up a major fraction of even a large hard disk.

But a more convenient storage medium now provides access to dozens of large databases and hundreds of images without putting a strain on your hard drive or making you do the floppy shuffle ("Now Insert Diskette #52"). Compact disks can hold up to 700 MB of data in their 12 centimeter diameter. You can't write to the disk — hence its name compact disk, read-only memory (CD-ROM) — but it's probably just as well or you might accidentally erase or corrupt the database.

Most astronomers and personal computer owners didn't use CD-ROMs until recently because CD-ROM drives were expensive and few astronomy disks existed. But most of the major astronomy software vendors have started to offer programs and databases on CD-ROM and prices for CD-ROM drives continue to drop. In fact, many new home computer systems include a CD-ROM drive.

In addition to their vast storage capability, CD-ROMs are cheap. The Hubble *Guide Star Catalog* with its 19 million objects would cost hundreds of dollars if you could purchase it as a series of books. It's available on CD-ROM for just $29.95. Obtaining prints of all the planetary images now available on CD-ROM would prove costly and difficult. And you couldn't manipulate the printed images the way you can digital ones with image-processing programs. Just be sure your program can read the data format (FITS, PDS, and ARN are the most common ones) for the CD-ROM.

The exciting part is that the disks listed below are just the beginning. Every day astronomers and software vendors are producing new disks. Soon you'll wonder how you got along without them.

CD-ROMS LET YOU ACCESS hundreds of megabytes of data such as images of the planets and catalogs of star and galaxy positions and magnitudes.

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Images	**Distributed by**	**Price**	**Format**	**Description**
Amazing Universe	Hopkins Technology	$ 79.95	—	101 images of planets and deep-sky objects
Voyage to the Planets — 1	Astronomical Research Network	$149.95	ARN	Jupiter, Saturn, Uranus
Voyage to the Planets — 2	Astronomical Research Network	$149.95	ARN	Neptune
Voyage to the Planets — 3	Astronomical Research Network	$149.95	ARN	Mars
Voyage to the Planets — 4	Astronomical Research Network	$149.95	ARN	Venus
Voyage to the Stars — 1	Astronomical Research Network	$149.95	ARN	galaxies
Voyage to the Stars — 2	Astronomical Research Network	$149.95	ARN	David Malin collection of deep-sky objects
Voyage to the Stars — 3	Astronomical Research Network	$149.95	ARN	IRAS infrared sky images
Voyage to the Stars — 4	Astronomical Research Network	$149.95	ARN	Rudy Schild collection of deep-sky objects
Comet Halley, Int'l. Halley Watch	National Space Science Data Center	$152	FITS, PDS and text	Halley Watch data on 23 disks
IRAS Sky Survey Atlas (ISSA)	National Space Science Data Center	$ 38	FITS	12.5° x 12.5° images on 4 disks
Pre-Magellan Venus data	National Space Science Data Center	$ 20	PDS	Radar and gravity data for inner planets on 1 disk
Magellan Venus data	National Space Science Data Center		PDS and VICAR2	Radar mosaic images on over 50 disks
Viking Orbiter images of Mars	National Space Science Data Center	$ 38	PDS	Images on 4 disks
Voyager Spacecraft to Uranus vols 1-3	National Space Science Data Center	$ 32	PDS	6,538 images on 3 disks
Voyager Spacecraft to Saturn vols 4-5	National Space Science Data Center	$ 26	PDS	4,000 images on 2 disks
Voyager Spacecraft to Jupiter vols 6-8	National Space Science Data Center	$ 32	PDS	6,000 images on 3 disks
Voyager Spacecraft to Neptune vols 9-12	National Space Science Data Center	$ 38	PDS	10,000 images on 4 disks
Joint Education Initiative - earth science	Robert Ridky, Univ. of Maryland	—	PDS	Halley Watch, Voyager, and other data on 3 disks
Space Science Sampler vols 1&2	Randal Davis, Univ. of Colorado	—	PDS	800 Uranus images from Voyager on 2 disks
Space and Astronomy	Walnut Creek CDROM	$ 39.95	—	1,000 images of Earth, the planets, and space shuttles
Catalogs				
Selected Astronomical Catalogs	National Space Science Data Center	$ 26	FITS and text	120 catalogs on 2 disks
Principal Galaxy Catalogue	Observatorie de Lyon	$ 90	—	Information about 73,000 galaxies
Hubble Guide Star Catalog	Astronomical Society of the Pacific	$ 29.95		Positions and magnitudes of over 15 million stars
Databases				
Flares in Hydrogen Alpha	National Geophysical Data Center	$111	text	Solar flare records dating back as far as 1938
Regions of Solar Activity	National Geophysical Data Center	$111	text	Calcium plage and sunspot group data — 1958 to 1991
Solar Radio Bursts	National Geophysical Data Center	$111	text	Solar radio emissions
Solar Variability Affecting Earth	National Geophysical Data Center	$111	text	Flares, spot numbers, and solar irradiance on 1 disk
Interactive Disk				
View from Earth	Warner New Media	$ 79.98	—	Describes Earth, Sun, and Moon with text and images

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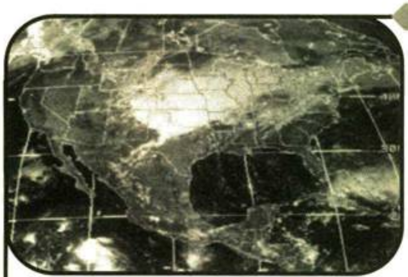
Planets Accurate telescope views of planets with phases, rings, and *all 20 planetary satellites* visible in a 24-inch telescope.



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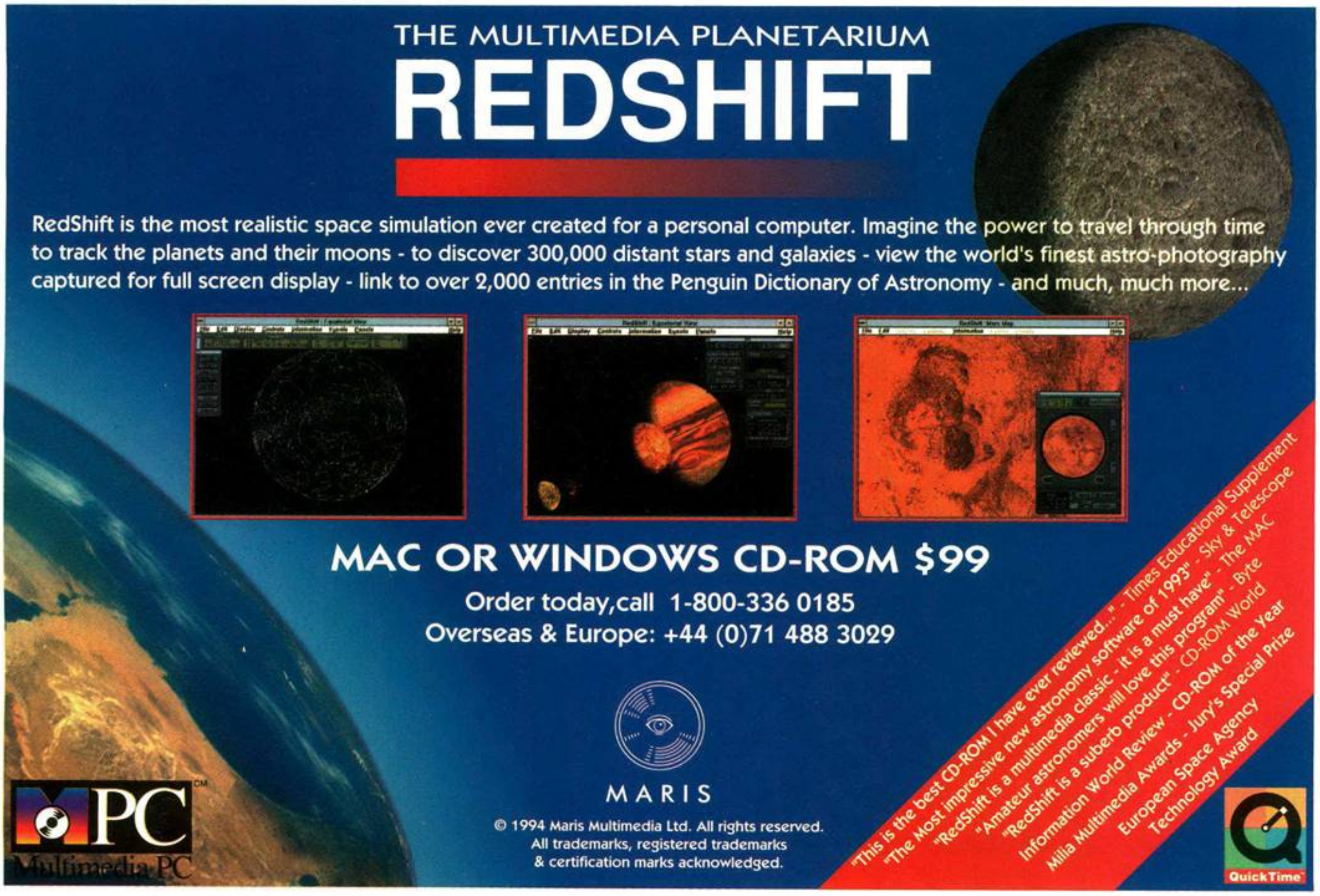

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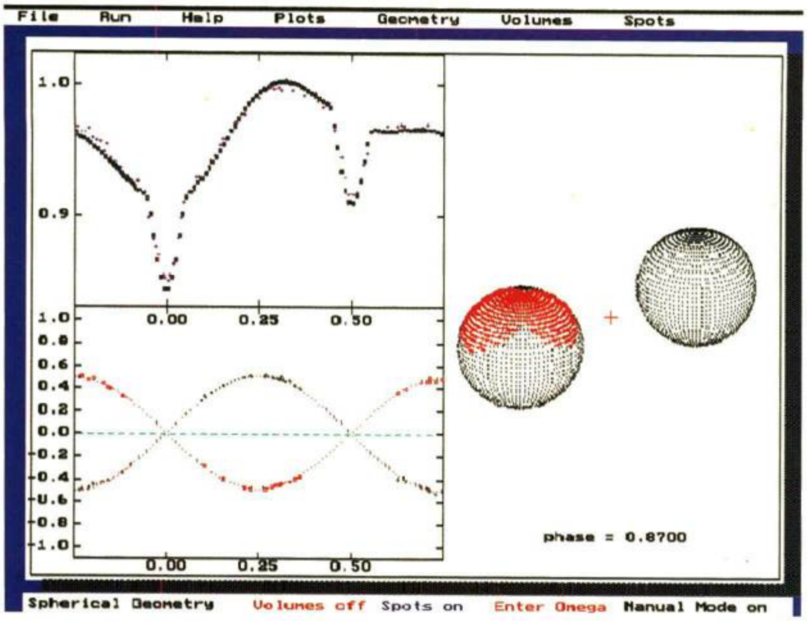
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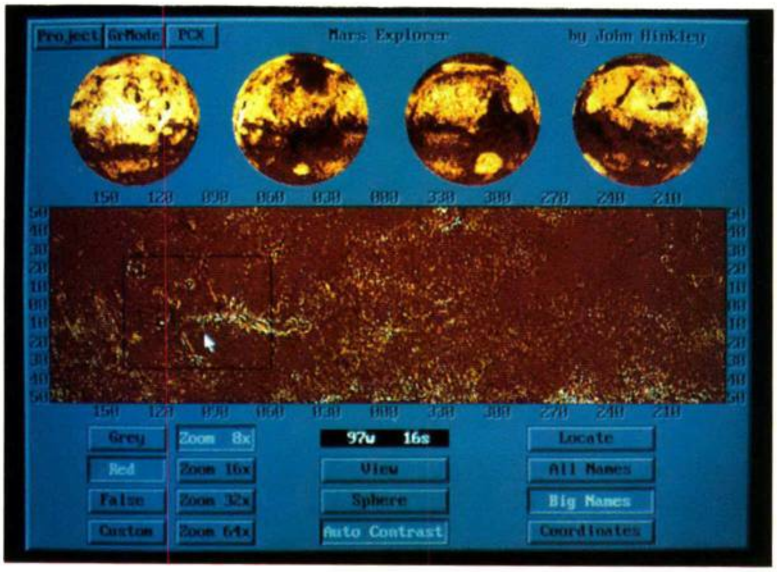
Binary Maker by Contact Software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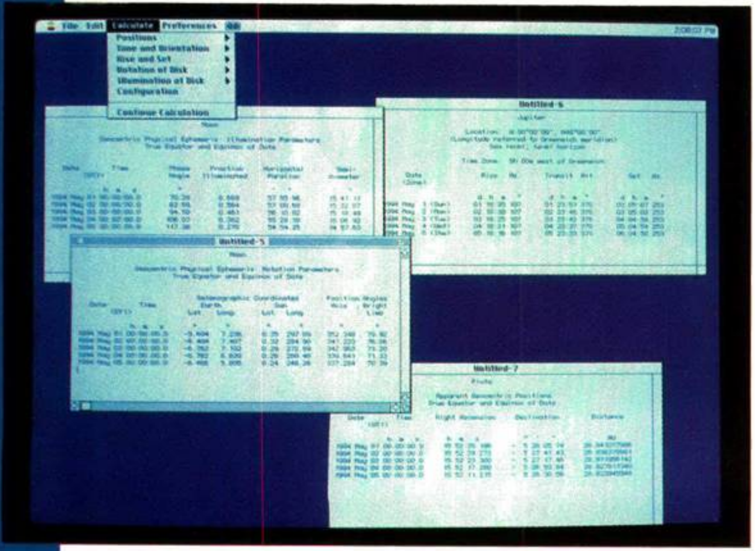
Mars Explorer by Virtual Reality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Untitled-6
Untitled-7

MICA from the National Technical Information Service

Many astronomers think of planetarium-type programs when they think of astronomical computing. But a wealth of special-purpose programs exists that goes beyond star charting and the animation of planetary motions. They let you tap into other areas of interest that you may have in astronomy. And some of them allow you to explore the nature of the universe in ways that no other program can.

Eclipse programs plot the path of a solar eclipse across Earth's face or predict the time of a lunar or solar eclipse more accurately than some planetarium-type programs. The program will tell whether the eclipse is partial, total, or annular (for solar eclipses) and the precise percentage of coverage, or magnitude, as seen from your location. You can also discover the limits of visibility of a lunar eclipse or the time of the next solar eclipse in a Saros cycle (the 18-year cycle of similar eclipses).

Orbital programs and gravitational simulators show the motions of two or more stars or galaxies around each other. They allow you to investigate what happens to a planet in a binary star system or to two binary star systems that collide. Some of these programs show two galaxies collide, permitting you to reproduce the appearance of some actual galaxy pairs such as the Antennae, the Mice, and polar ring galaxies. Or you can study the dynamics of a star system as it coalesces or diffuses into space.

Specialized observing programs help out deep-sky, asteroid, and variable star observers. These programs let you keep and access detailed observing logs, determine the position of an object in a photograph, or track the brightness of a variable star. If you want to learn why the brightness variations of eclipsing binary stars are so complex, a program will show how the stars pass in front of each other and how spots might change brightness of the star system. Other programs will locate a multitude of asteroids and determine their brightnesses.

If you're an astrophotographer, several programs will help you calculate exposure times for different types of objects. These programs can also tell how much sky a lens or telescope-eyepiece combinations will cover. If you're uncertain about which eyepiece to use to split a close double star or what the eyepiece's field of view is, a program can help.

Several programs will tell you when it's best to observe a planet, calculating rise and set times and the time the planet crosses your local meridian. They can also provide you with the longitude of a planet's central meridian, which is important to know if you're looking for certain features such as Jupiter's Great Red Spot or Martian volcanoes.

A program can determine the times when the

Moon may occult or pass in front of a bright star as seen from your location. Other programs can show the positions of the moons of Mars and Jupiter — and the times of possible eclipses and occultations by the planet — before you go out to look for them.

Calendars help you find the dates of the New Moon for planning deep-sky observing sessions or other phases for lunar observing. Other calendar programs translate between different calendrical systems, such as Gregorian, Julian, Chinese, Japanese, Hebrew, and Islamic, which is important if you want to trace celestial events recorded by ancient astronomers.

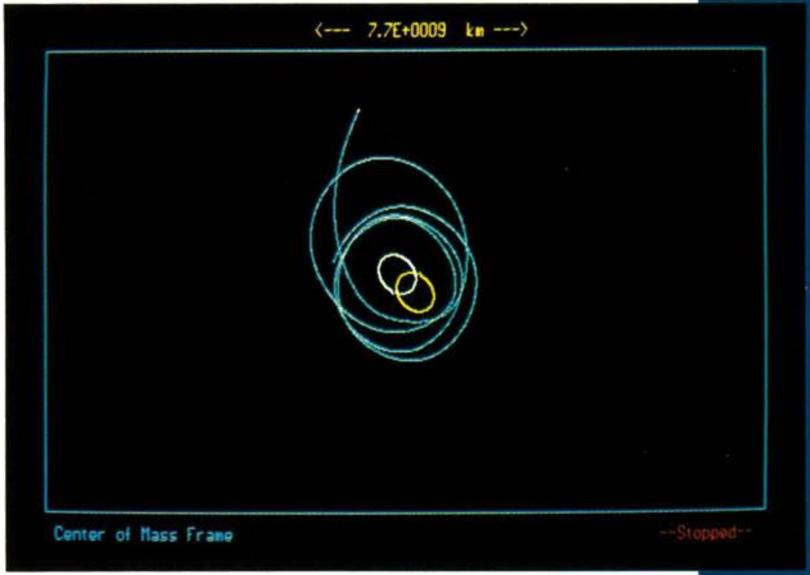
Want to build a planet? Software makes it easy to explore what happens to a planet if volcanos spew too much — or not enough — carbon dioxide into the atmosphere or if plate tectonics make the continents drift faster than those on Earth. Such simulations let you find out how life may have differed from its present form or how life might have developed on Mars.

If you want to observe satellites, a multitude of programs *will* help you track the orbital paths of the space shuttle and other Earth satellites. These programs list when and where to look to see these objects as they race across the sky. Other programs access the images sent back to Earth by weather satellites, which some amateurs find useful for planning special observing sessions and others enjoy for their picturesque nature. Other space-related programs simulate a spacecraft mission such as Voyager's trip to Jupiter, Saturn, Uranus, and Neptune.

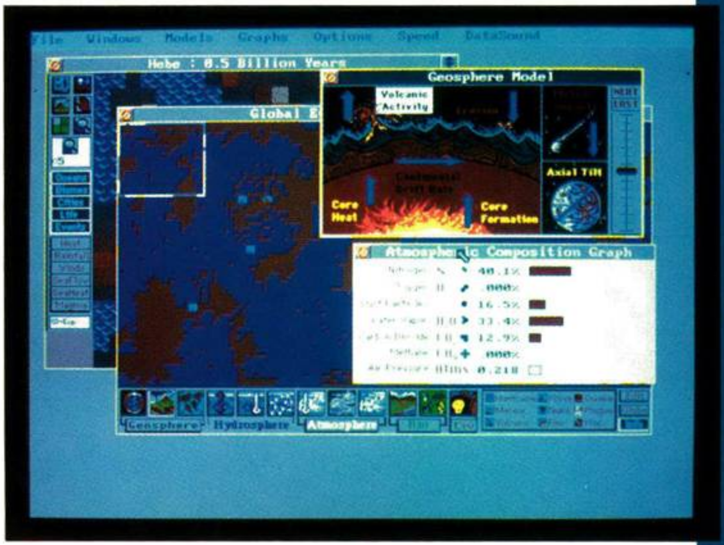
Planetarium-type programs allow you to see what the universe looks like from Earth. A few will let you move off Earth to view the night sky from another planet or a point within the solar system. But a special-purpose program permits you to discover the nature of our Local Group of galaxies and how it fits into the local structure of the universe. Another shows our neighborhood of the Milky Way Galaxy from the vantage point of any star in the region. See how the constellation patterns change as you move through space.

You can learn how a telescope works with optical ray tracing programs that show how individual beams of light reflect or refract through a scope's optics. These programs also let you explore the differences between the types of refracting and reflecting telescopes, including advanced apochromatic and catadioptric telescopes. Tracing different color light rays or rays that pass through different parts of the optics allows you to study possible aberrations in a scope. Other programs allow you to explore the physics of stars and how they emit light or study the intricacies of Einstein's theory of special relativity.

And if all this isn't enough to provide you with many evenings of enjoyment, various programs provide an astronomical encyclopedia that can help you learn about the objects you see in the night sky. Or for a break from the thoughtful side of astronomy, you can relax with astronomically oriented games. If you haven't done so already, put away that planetarium-type program for a while and let these special-purpose programs expand your interests.



Orbits by Physics Academic Software



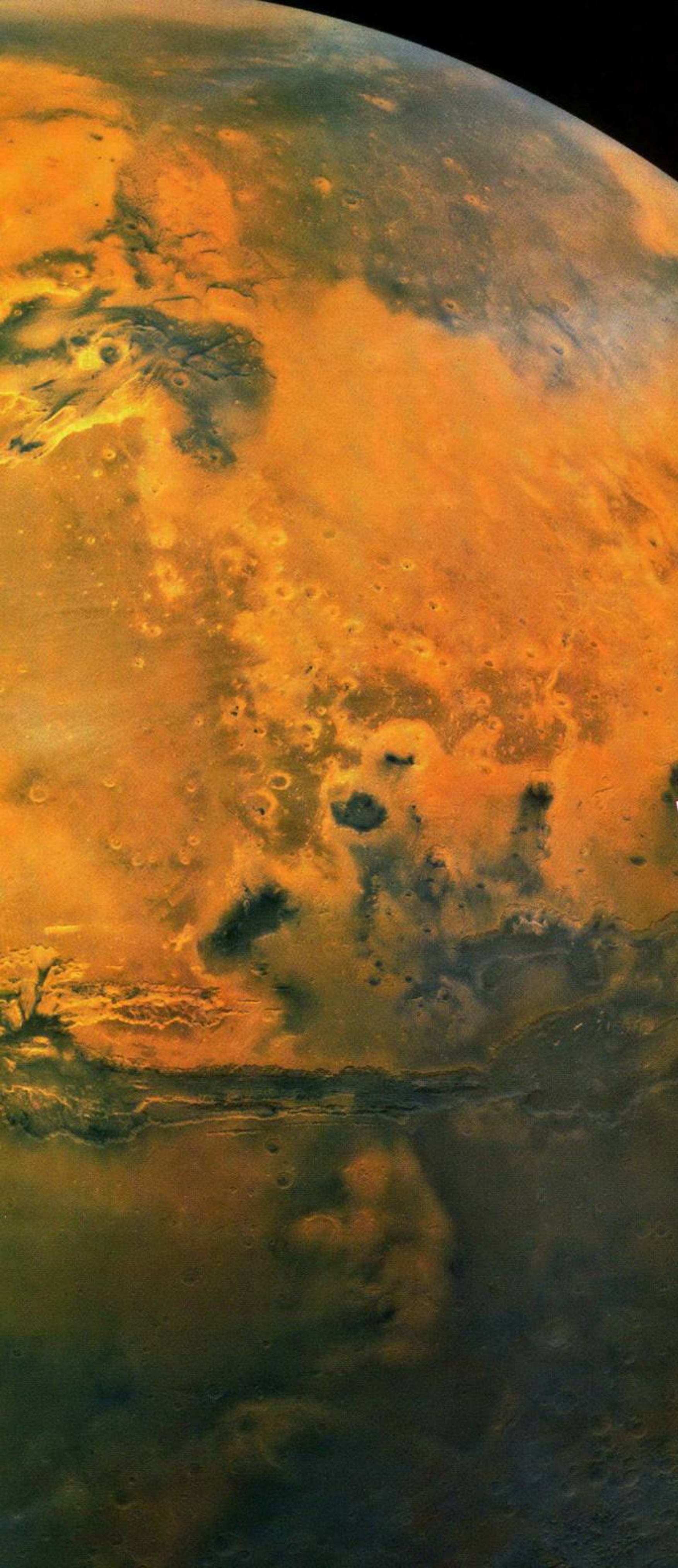
SimEarth by Maxis

Vista Pro by Virtual Reality

OTHER ASTRONOMY SOFTWARE

Program Name	Developer	Price	Comp	System	H. Drive	Mem	Display	Description
AstroCalc	Zephyr Services	$ 30-$200	PC	DOS	no	—	CGA-EGA	Gives planetary positions, rise and set times
Astronomy Lab	Pers. MicroCosms	$ 15	PC (286)	Win 3.1	1MB	1MB	—	Predicts astronomical phenomena
Astronomy Workbench	Io Solutions	$125	PC	DOS	—	—	EGA	Displays the night sky and simulates orbits
AstroPhoto	Zephyr Services	$ 29.95	PC	DOS	no	—	—	Calculates exposure times
AstroPix	F.C. Meichsner Co.	$ 39.95	PC	DOS	no	—	—	Computes exposure times for astrophotos
AstroPlanck	Zephyr Services	$ 29.95	PC	DOS	no	—	VGA	Demonstrates how stars radiate energy
AstroPoint IV	Dale Ferguson	$ 29.95	PC	DOS	no	—	CGA	Calculates positions of objects in the sky
AstroSheet	C.E.B. Metasystems	$299.95	PC	Win	—	—	—	Uses Microsoft's Excel for calculations
Astro-3D	Zephyr Services	$ 30-$40	PC	DOS	no	—	CGA-EGA	Travels through the Sun's neighborhood
Beam 2	Stellar Software	$ 89	PC	DOS	no	—	—	Traces light through optical systems
Beam 2	Stellar Software	$ 89	Mac	—	—	—	—	Traces light through optical systems
Binary Maker	Contact Software	$ 59.95	PC	DOS	no	640KB	VGA	Simulates binary star orbits and brightnesses
CalMaster 2000	Zephyr Services	$ 49.95	PC	DOS	no	—	VGA	Compares different calendrical systems
Canon of Eclipses	Willmann-Bell	$ 29.95	PC	DOS	no	640KB	CGA	Displays lunar eclipses, 1500 B.C.-A.D. 3000
Ceres	Zephyr Services	$159.95	PC	DOS	7MB	—	EGA	Plots paths for over 5,000 asteroids
CircumSpace	KlassM Software	S	PC	DOS	no	640KB	EGA	Travels through the Sun's neighborhood
Dark Sky Calendar	Steve Voss	$ 24.50	PC	DOS	no	—	—	Prints monthly calendar with Moon phases
Discover Space	Brøderbund	$ 59.95	PC	DOS	—	—	—	Tours the solar system
Eclipse Live	Andrew Lowe	$ 39.95	PC	DOS	—	—	—	Displays solar eclipses accurately
EclipseMaster	Zephyr Services	$ 30-$50	PC	DOS	no	—	—	Computes solar and lunar eclipses precisely
Electronic PictureBooks	Astr. Soc. Pacific	$ 10-$40	Mac	7.X	yes	2.5MB	—	Contains images of planets and other objects
GalaxCrash	Zephyr Services	$ 30-$50	PC	DOS	no	—	CGA-EGA	Simulates collision of two galaxies
Galileo's Four	Zephyr Services	$ 29.95	PC	DOS	no	—	CGA	Shows positions of Jupiter's largest moons
Gauss and Laplace	Andromeda Software	S	PC	DOS	no	—	—	Computes orbit from three observations
Gravitator	Zephyr Services	$ 40-$150	PC	DOS	no	—	CGA-EGA	Computes orbits of stars and planets
Howington Orrery	Zephyr Services	$ 39.95	PC	DOS	no	—	CGA	Displays orbits in our solar system
Image files	Andromeda Software	S	—	—	—	—	—	Contains GIF images of planets
JMoons	Andromeda Software	S	PC	DOS	no	—	EGA	Shows positions of Jupiter's largest moons
Jovian Traveler	Zephyr Services	$ 49.95	PC	DOS	no	—	CGA	Simulates spacecraft mission to Jupiter
Learn About Orbits	Andromeda Software	S	PC	DOS	no	—	EGA	Teaches concepts of orbital motion
MarsEGA	Andromeda Software	S	PC	DOS	no	—	EGA	Locates moons of Mars
Mars Explorer	Virtual Reality	$ 69.95	PC (386)	DOS	no	4MB	VGA	Maps Mars' surface; need CD-ROM drive
MICA	NTIS	$ 55	Mac	6.0.2	2MB	1MB	—	Computes precise planetary positions
MICA	NTIS	$ 55	PC	DOS	2MB	512KB	—	Computes precise planetary positions
MoonTracker	Zephyr Services	$ 30-$40	PC	DOS	no	—	CGA-EGA	Displays lunar eclipses and visibility
Optics Lab	Sci. Lab Software		PC (386)	Win. 3.1	644KB	—	—	Traces light through optical systems
Orbits	Soft. Marketing Corp.	$ 59.95	PC	DOS	no	512KB	EGA	Provides information about the solar system
Orbits	Phy. Acad. Software	$ 59.95	PC	DOS	no	384KB	CGA	Simulates orbits of stars and planets
Our CosmoHood	Bondono Software	$ 25	PC	DOS	600KB	—	EGA	Shows our Local Group of galaxies
PC GOES/WEFAX	Soft. Systems Cons.	$250	PC	DOS	no	640KB	CGA	Captures weather satellite images
PC-Track	Andromeda Software	S	PC	DOS	no	—	EGA	Tracks Earth satellites
PEEP	C.E.B. Metasystems	$ 39.95	PC	DOS	yes	640KB	EGA	Finds eclipses, conjunctions, occultations
Personal Observing Log	Ohio Star Software	$ 20	PC	Win	no	—	—	Records your observing notes
Planets III	Aladdin Software	$ 39.95	PC	Win	3MB	2MB	—	Shows pictures of and describes the planets
Planet Tracker	David Chandler	$ 3/demo	PC	DOS	no	512KB	EGA	Investigate the laws of planetary motion
Plate	Zephyr Services	$ 49.95	PC	DOS	no	—	—	Determines position of object in photo
Satellite Pro	Zephyr Services	$149.95	PC	DOS	yes	—	EGA	Calculates highly accurate satellite orbits
Satellite Tracker	Intellimation	—	Mac	6.0.5	yes	IMB	—	Tracks Earth satellites
Scope	Waldee-Wood	$ 49.95	PC	DOS	no	384KB	CGA	Calculates performance of telescope
Silicon Universe	Algol Software Works	$ 12	PC	DOS	no	—	—	Shows deep-sky objects outside our Galaxy
SimEarth	Maxis	$ 69.95	Mac	—	—	1MB	—	Creates a planet that then evolves
SimEarth	Maxis	$ 69.95	PC	DOS	—	640KB	EGA	Creates a planet that then evolves
SkyClock	Bodhi Software	$ 79.99	PC	DOS	no	512KB	—	Provides rise and set times for planets
Solar	Andromeda Software	S	PC	DOS	no	—	CGA	Displays solar eclipses from 1951 to 2032
SolarSpace	Zephyr Services	$ 39.95	PC	DOS	no	—	EGA	Shows Sun's neighborhood in 3D
SolarSys	Zephyr Services	$ 29.95	PC	DOS	no	—	VGA	Surveys the contents of the solar system
Space Adventure	Knowledge Adventure	$ 59.95	PC	DOS	7MB	—	VGA	Provides a tour of the universe
Spacetime	Phy. Acad. Software	$ 59.95	Mac	—	—	—	—	Explores the laws of special relativity
Spacetime	Phy. Acad. Software	$ 59.95	PC	DOS	no	—	—	Explores the laws of special relativity
StarBase	Altair Engineering	$199	PC	Win	—	—	—	Stores your observations, images, and text
StarCrossed	Zephyr Services	$ 29.95	PC	DOS	no	—	VGA	Introduces variable stars
STS-Orbit	Andromeda Software	S	PC	DOS	no	—	CGA	Displays shuttle orbital paths
SunTracker	Zephyr Services	$ 30-$130	PC	DOS	—	—	CGA-EGA	Displays solar eclipses and paths
TideMaster	Zephyr Services	$ 39.95	PC	DOS	no	—	—	Calculates times of high and low tides
TimeChecker	Zephyr Services	$ 39.95	PC	DOS	no	—	—	Gets correct time from U.S. Naval Obs.
Total Eclipse	Zephyr Services	$129.95	PC	DOS	yes	—	EGA	Displays solar and lunar eclipses
TrakSat	Zephyr Services	$ 89.95	PC	DOS	no	—	CGA	Follows Earth satellites in their orbits
VarBase	Zephyr Services	$ 29.95	PC	DOS	no	—	CGA	Records and displays variable star data
Vista Pro	Virtual Reality	$129.95	PC	DOS	3MB	4MB	VGA	Creates Martian landscapes from Viking data
Where in Space	Brøderbund	$ 79.95	PC (386)	DOS	8MB	640KB	VGA	Presents a game set in the solar system
WinTrak	WinTrak	$ 49.95	PC (286)	Win	3MB	2MB	VGA	Tracks Earth satellites

An "S" in the "Price" column indicates that the program is shareware. If you like the program and wish to keep it, you must register your copy with the developer and pay the fee listed with the program documents. "Display" lists the minimum display required. The program may support higher video modes.



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In addition to plotting stars, processing images, and running telescopes, computers can keep you in touch with other astronomers. Many clubs and organizations provide a bulletin board service (BBS) where you can dial into their computers and share programs, leave messages on the bulletin board, or "talk" directly to others in a forum or conference. All you need is a modem and a communications program. This list provides you with the phone number, the data transfer rate (baud rate) and the number of data bits/parity/stop bits needed to set your modem properly. All of these bulletin boards provide free service (although you have to pay the cost of the telephone call); some have additional services for which you must pay a small fee.

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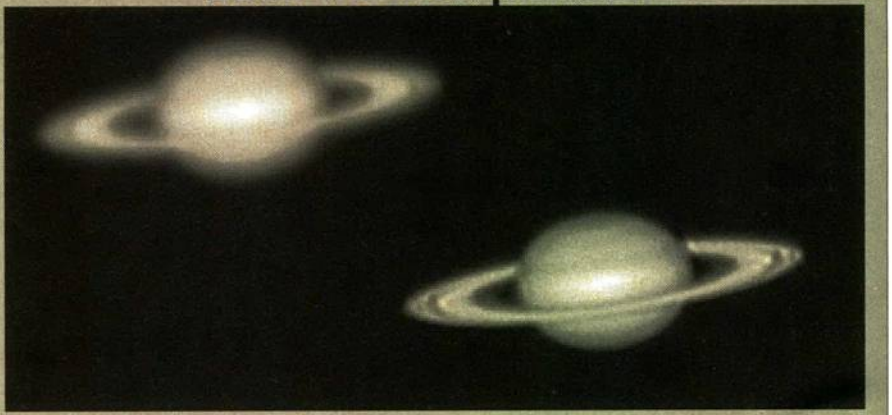

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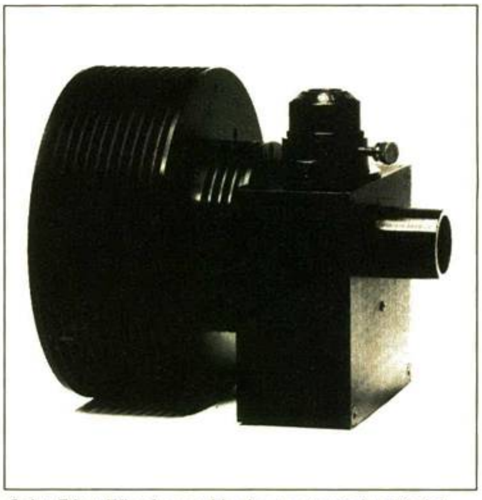

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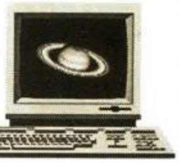

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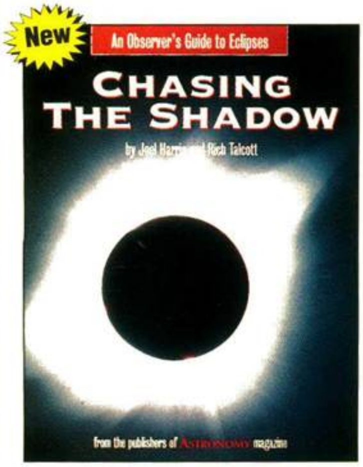
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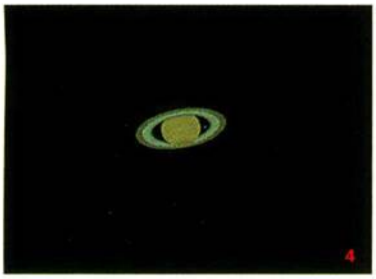

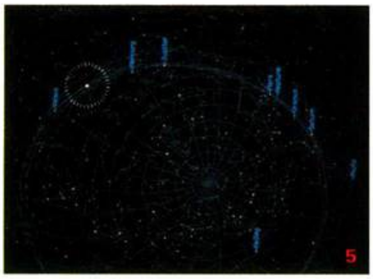

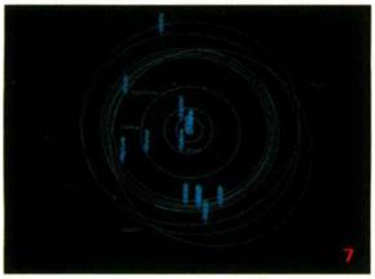

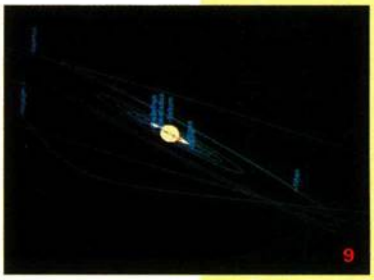

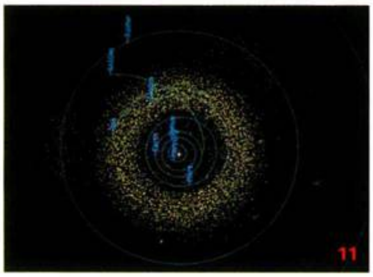

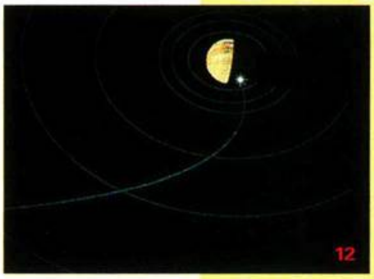

Unretouched screen shots from Dance of the Planets.

1 Dawn from Xi'an, March 3, 1953 bc. The new moon and a grand planet alignment began the Chinese calendar.

2 The closest known Earth-asteroid passage, less than half the distance to the moon. 1993ka2 is actually in the foreground exaggerating the closeness.

3 Lunar eclipse in Taurus on Nov. 29, 1993.

4 The star 28 Sgr in the "right elbow" of Saturn (north is down). From Colorado, July 3, 1989, 2 a.m.

5 Skymap showing planet epicycles and comet Halley's path from Jan. 1, 1985 to Apr. 20, 1986.

6 Lunar occultation of Jupiter, Oct. 7, 1994 from the southern hemisphere. Note Galilean moons.

7 A less familiar solar system. Orbits of newly discovered Kuiper belt planetesimals shown.

8 July 29: Mars at western stationary position before the excellent opposition of 2003. Note phase.

9 November, 1980. After passing directly below Titan, Voyager 1 is deflected up out of the ecliptic by Saturn's gravity.

10 July 25, 1779. This earliest known Jupiter-comet strong perturbation ejects Lexell's comet from the solar system.

11 The asteroids on July 16, 1994. Note the positions of the Galileo spacecraft and the earlier imaged asteroids Gaspra and Ida.

12 20 fragments of Shoemaker-Levy 9 on July 16, 1994. Viewing angle is below Jupiter and nearly along the comet path, making the fragments appear closer together than they actually are.

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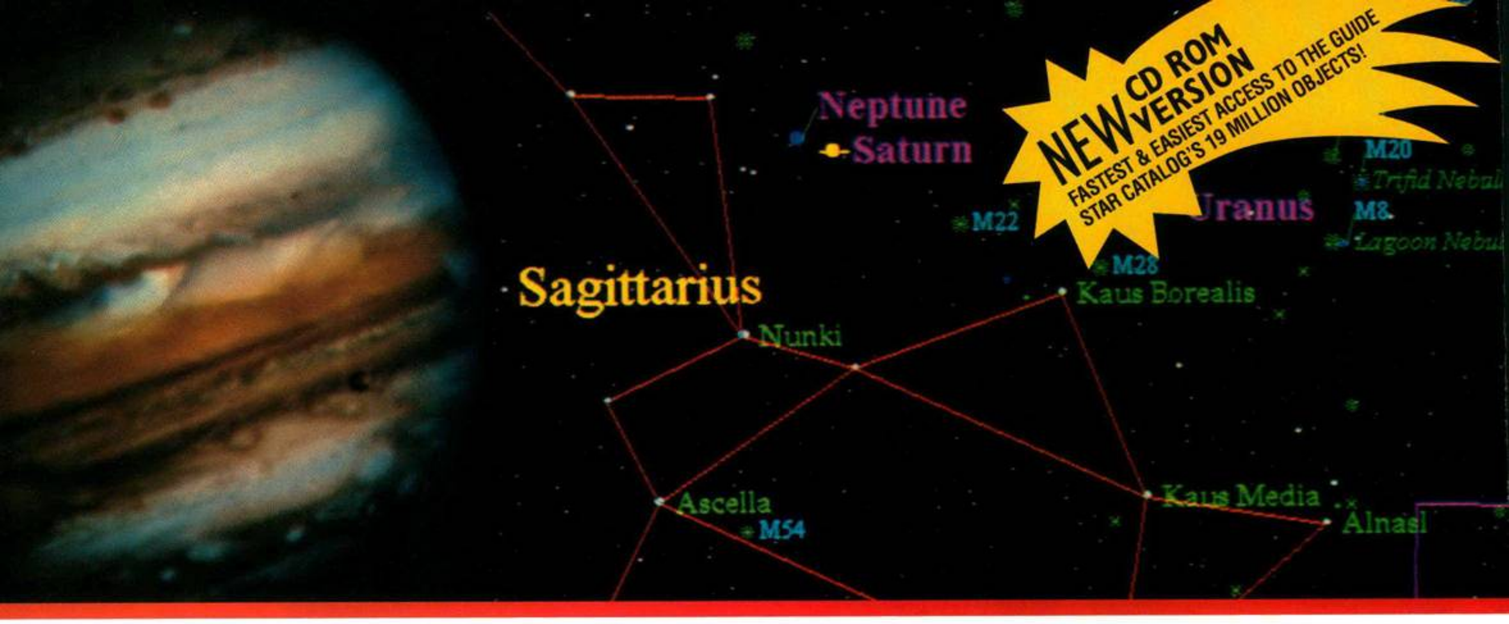
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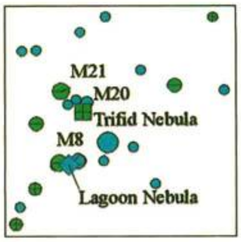

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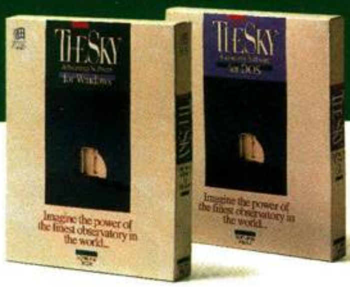
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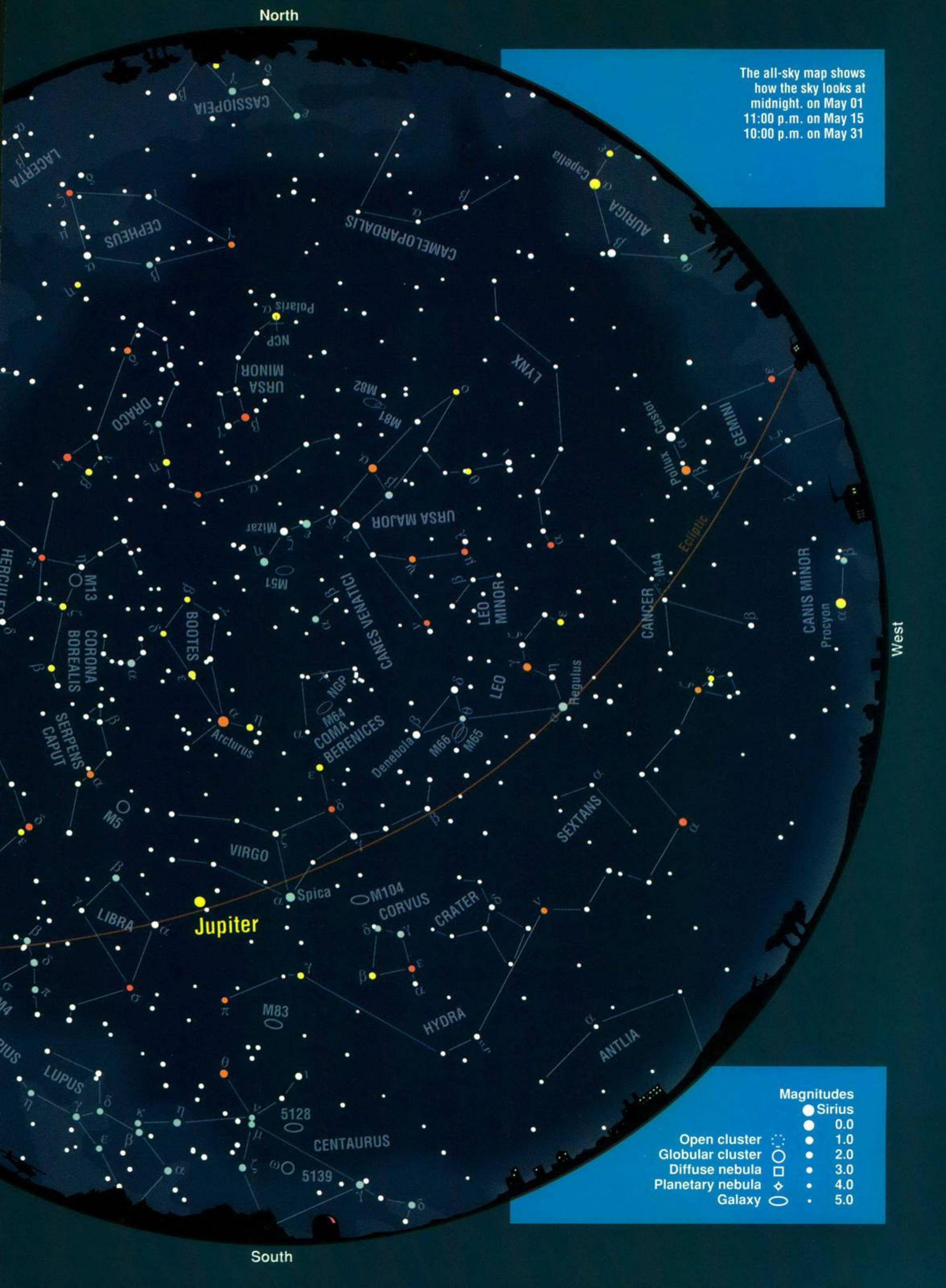

The all-sky map shows how the sky looks at midnight. on May 01 11:00 p.m. on May 15 10:00 p.m. on May 31

North
South
West
CASSIOPEIA
LACERTA
CEPHEUS
CAMELOPARDALIS
AURIGA
Capella
Polaris
NCP
URSA MINOR
DRACO
LYNX
M82
M81
GEMINI
Castor
Pollux
URSA MAJOR
Mizar
M51
M13
HERCULES
CANES VENATICI
LEO MINOR
CANCER
M44
Ecliptic
CANIS MINOR
Procyon
BOOTES
CORONA BOREALIS
SERPENS CAPUT
NGP
M64
COMA BERENICES
Arcturus
LEO
Regulus
Denebola
M66
M65
M5
SEXTANS
VIRGO
Spica
M104
CORVUS
CRATER
LIBRA
Jupiter
HYDRA
M83
ANTLIA
LUPUS
5128
CENTAURUS
5139
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

SKY ALMANAC

by Deborah Byrd and Jeff Kanipe

Get ready for a spectacular event. In the midday hours of May 10 you'll see the Moon pass directly between us and the Sun, creating an eclipse. Unlike a total eclipse, however, this month's is an annular eclipse. An annular eclipse occurs when the Moon is relatively distant and does not fully cover the Sun's disk, leaving a ring, or annulus, of sunlight. At mid-eclipse on May 10, the Moon is only 39 hours past apogee, its farthest point from Earth.

Annular eclipses sweep over a wide swath of land as the shadows of total eclipses do. During this month's eclipse the path first strikes Earth's surface at sunrise in the Pacific Ocean southeast of Hawaii and then passes over Mexico, crossing the border into the United States near El Paso. There the shadow path is about 160 miles wide, and annularity lasts 5.7 minutes. The path then sweeps across the United States toward Lake Erie. Near Toledo, Ohio, annularity lasts longest, just over 6.2 minutes, and the shadow path narrows to about 140 miles. Outside this path, observers can see a partial eclipse throughout North America and in western Europe, northwest Africa, Iceland, Greenland, and extreme eastern Siberia.

Some eclipse chasers believe annular eclipses are less dramatic than total eclipses. This isn't so. For example, observers witnessed a thrilling annular eclipse from the deep South on May 30, 1984. As mid eclipse approached, the land and sky darkened and colors shifted to new and surprising hues. Gaps in the leaves of overhanging trees made pinholes that projected the Sun's image. Crescent suns danced on the ground.

Look for these effects if you are in or near the path of this month's eclipse. Also, watch for strange behavior in animals, drops in temperature, wind changes, and the shifting shapes of clouds. These phenomena help give a dreamlike quality to the experience of seeing an eclipse, whether annular or total.

Be mindful of safety, however. An annular eclipse is a partial eclipse in that the Sun is never completely covered. As with any partial eclipse, you cannot look at the Sun directly at any time without a filter. Buy commercial filters for use with binoculars and telescopes, or use #14 welder's glass for viewing with the naked eye. This month's event provides a fabulous opportunity to witness one of nature's spectacular shows. The next total solar eclipse visible from the United States will come on August 21, 2017.

This month offers not one but two eclipses. On May 24, the dark umbral shadow of the Earth brushes the southern limb of the Moon, creating a partial lunar eclipse. It's fun to be outside when the first dark bite appears on the Moon. That happens at 10:38 p.m. EDT. Then just relax and watch the dark creep more deeply onto the Moon's face. Maximum eclipse comes at 11:30 p.m. EDT. At this time, about 25 percent of the Moon will appear darkened.

The partial lunar eclipse will be visible in nearly all of the United States with the exception of Alaska and Hawaii. The entire event is visible east of a line from San Diego to the northeastern corner of Montana. West of that line, the Moon rises with the eclipse in progress. You won't need special equipment to see this lunar eclipse, but binoculars or a telescope enhance the view.

Likewise, you won't need special equipment to see some flashy meteors in the annual Eta Aquarid meteor shower. The shower peaks on the morning of May 5, and you should be able to spot at least several meteors per hour from a dark location.

The meteors appear to come from a point near the Water Jar asterism of the constellation Aquarius. Unfortunately, the Moon hovers near Aquarius on the morning of the shower's peak activity. However, the slender Moon will be only 22 percent illuminated that day, so it won't interfere too badly.

After passing through New on May 10, the Moon becomes visible again as a fragile crescent in the evening sky hovering near

Annular Eclipse of the Sun

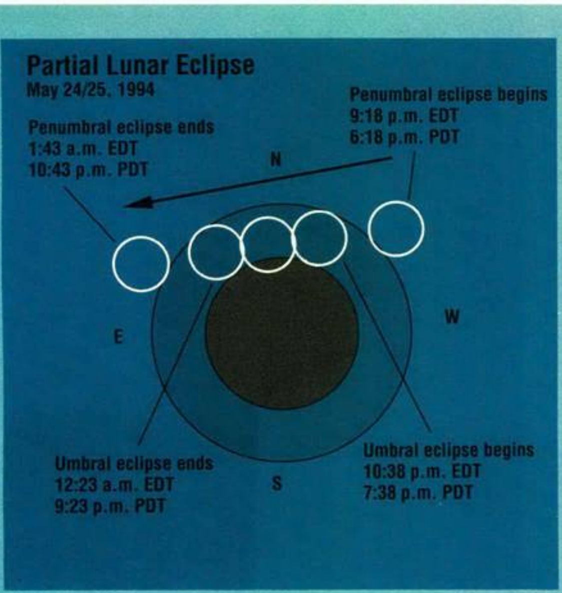
On May 10, observers in the Western Hemisphere will see the Moon slide across the Sun's disk. Because the Moon is relatively distant at the time, the result will be an annular eclipse, one that leaves a bright ring of sunlight encircling the dark lunar profile. The eclipse's path bisects the continental United States diagonally, so there's no excuse to miss this event. See "May's Ring of Fire" (page 92) for complete eclipse coverage, including a table providing the local circumstances and times to watch the eclipse for specific cities in the United States, Mexico, and Canada.

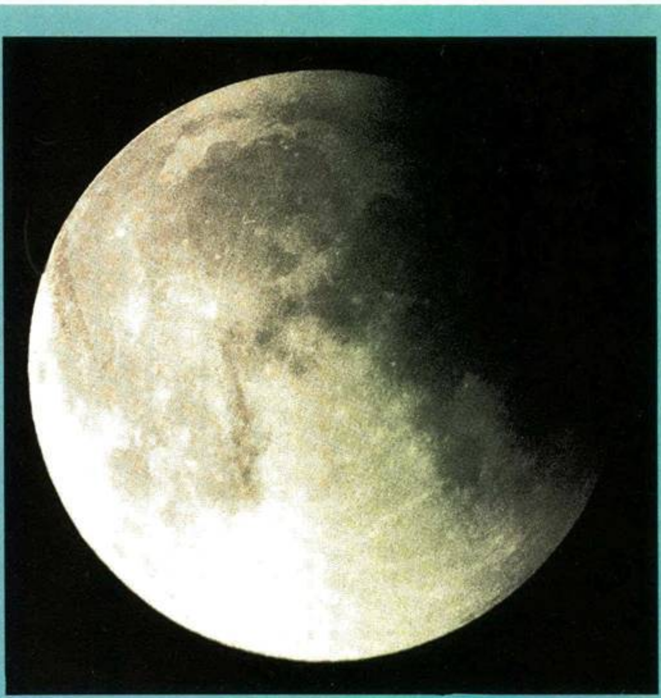
The Moon's shadow races over North America from northern Mexico and the American Southwest, through the Midwest and Great Lakes, New England, maritime Canada, and on through the Azores. The eclipse ends at local sunset in Morocco. No matter where you are in the United States, on either side of the path of annularity, you'll see at least a partial eclipse.

Observers in the path of annularity will see maximum coverage of the Sun by the Moon, but they won't see the Sun totally eclipsed. The geometry is wrong. On the 10th, the Moon will be in the most distant part of its elliptical orbit. The extra distance shrinks the Moon's apparent size enough so that it is slightly less than the Sun's. The smaller diameter creates a dazzling ring of sunlight rimming the Moon at maximum eclipse. It's not a total eclipse, but it nonetheless provides a compelling sight to behold.

Dewey Vanderhoff

Because the Sun is not fully covered, however, viewing an annular eclipse calls for precautions. The annulus of sunlight is enough to cause permanent eye damage if viewed without proper protection. You may either project the Sun's image onto a card using a small telescope or view it directly through a piece of #14 welder's glass. Those planning to observe the event through a telescope should purchase a mylar or optical glass solar filter, which fits over the telescope's front end. The over-the-aperture filter method is the safest way to view the eclipse. It's also easier on your optics than projecting the Sun's image. This can, over the course of a few minutes, heat up your telescope's optics, damage eyepiece coatings, or melt the cement holding the eyepiece lens elements together.





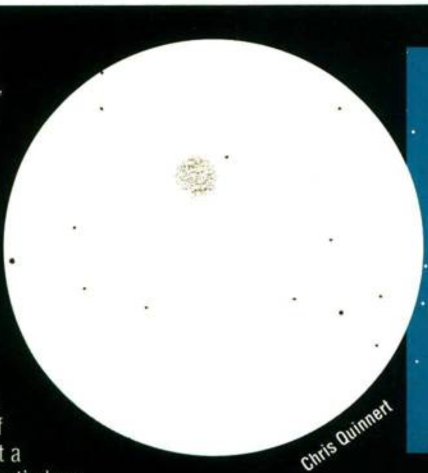
Richard Pomeroy

A Partial Lunar Eclipse

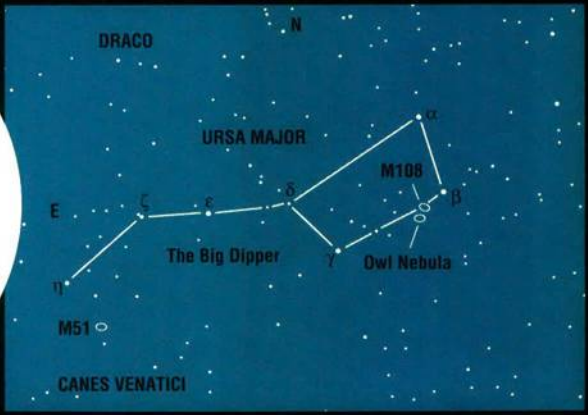
Another shadow dance of the Sun and Moon takes place on the evening of May 24 and continues into the early morning hours of May 25. The Moon's southern quarter dips into the dark central cone of Earth's shadow, creating a partial lunar eclipse. At the time of the eclipse the Moon will stand about 7° north of Antares, the brightest star in Scorpius. The eclipse begins with the first, imperceptible penumbral contact at 9:18 p.m. EDT. But the show really gets going when the Moon first touches the umbra a little over an hour later at 10:38 p.m. EDT. The partial eclipse ends when the Moon quits the umbra at 12:23 a.m. EDT on the 25th.

This eclipse will be widely visible across the United States, although the penumbral phases begin before moonrise for observers in the western United States and Canada. For observers in western Europe, the Moon sets during the eclipse. The Moon will be quite bright, so the eerie contrast between the brightening stars and dimming Moon won't be quite as striking as it was during last November's total lunar eclipse. Still, the eclipse will provide astrophotographers with a pretty scene.

Find the Owl Nebula



Chris Quinnert



Of all the Messier objects, one of the most challenging, and rewarding, is the Owl Nebula, M97, in Ursa Major. M97 is a planetary nebula that lies relatively close to our Sun, so it is one of the largest such deep-sky objects visible in backyard telescopes. (See "Ashes to Ashes and Dust to Dust," page 40.) Although the Owl Nebula has a relatively bright magnitude of 11.2, you may find spotting it a challenge because of the object's low surface brightness. That is, the nebula's light spreads over a large area. In telescopes under eight inches in diameter, the Owl appears rather featureless, although its disk shape and two dark patches representing "owl eyes" should be apparent in an 8-inch telescope from a dark sky site. Using a narrow passband light-pollution filter such as Lumicon's UHC or Orion's UltraBlock makes the nebula stand out in higher contrast.

With or without a filter, it's best to start by using moderate magnifications of 75x to 150x. The Owl Nebula forms the apex of a right triangle with two 8th-magnitude stars that lie northeast and southeast of it. Observers with setting circles can center the field of view on 52 Ursae Majoris, a 4th-magnitude star, and move northward 10 1/2° in declination. That will put you in the area of the Owl Nebula. Look for a faint circular glow of gray light, almost like a chalk smudge on a blackboard. The two dark patches within the nearly translucent disk, the owl's eyes, stand on either side of the central star, which glows weakly at magnitude 14. You can glimpse the central star under a dark sky with a 10-inch telescope. You may also see an equally faint, cigar-shaped glow just 50' northwest of the Owl. This is M108, an edge-on spiral galaxy, and yet another challenging deep-sky object of the spring sky.

the planet Venus. On the evening of May 12 you'll have the opportunity to look for a very young Moon hanging low in the western sky after sunset. You can't miss the young Moon alongside Venus if you look early in the evening, before the pair sinks below the horizon.

On this same evening another member of our solar system floats near the horizon as twilight fades from the western sky. Mercury can be found below and right of Venus and the Moon, and it appears to the lower right of Venus all month. It spends the month ascending in the western twilight sky but never reaches as high in the sky as Venus. It's still 9° below Venus at greatest elongation from the Sun on May 30.

You can see one of the year's brightest periodic comets this month. Comet Tempel 1's closest approach to Earth occurs on May 5, after which the comet will continue to brighten. Look for Tempel 1 through your telescope or binoculars as a patch of fuzz whose position shifts slightly night by night. (See the box on page 85 for a finder map.)

This month's featured asteroid is one of the earliest discovered. It is 6 Hebe, and, like a comet, it moves nightly among the stars. But true to their names, asteroids appear starlike. When you track the motion of this asteroid from night to night, remember that you're standing on a body in space that, seen from any other position in the solar system, would also appear to move among the stars. (See the box on page 85 for a finder map.)

May's Planets

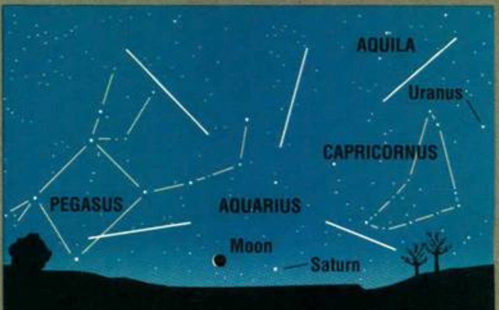
Mercury is the nearest planet to the western horizon after sunset, after about the first week of May. Try to see it to the lower right of the Moon on May 11. It is brightest toward the first part of the month, but it spends the month getting higher in the west after sunset, thereby becoming easier to see. On

Springtime for Meteors

The annual Eta Aquarid meteor shower peaks this year on May 5. Typically observers see 30 meteors per hour from a dark sky site. Unfortunately, a waning crescent Moon hangs in the morning sky on the 5th and this will dampen the display a bit.

The best time to see the maximum number of meteors will be in the after-midnight hours of May 4 and May 5, as Earth's night side turns into its orbit and sweeps up the largest number of meteoroids.

Though Aquarius rises around 2:30 a.m., you may start to see some meteors soon after midnight. The radiant, or point in the sky from which the meteors appear to come, lies near the 4th-magnitude star — you guessed it — Eta Aquarii. If you scan the sky with wide-field binoculars, you might see some meteors zip through the field of view. But the greatest chances for seeing meteors occur when you simply lie back and watch the sky overhead with no optical aid. A few of the brighter meteors will likely leave brief glowing trails in their wake.



Eta Aquarid Meteors
Looking east, morning of May 5

ETA AQUARID METEORS

Peak: May 4, 11 p.m.
Radiant: 22h27m, 0°
Zenithal hourly rate: 30
Moon: Waning gibbous, 26% illuminated

Mercury in the Evening Sky

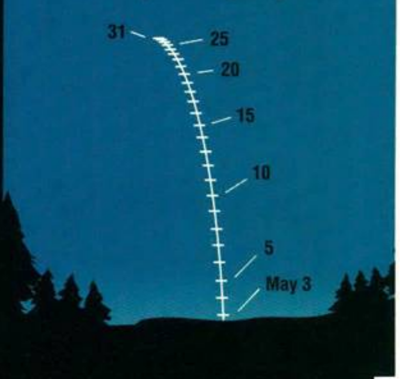
This year Mercury shows its face to greatest advantage for observers in the Northern Hemisphere when it reaches greatest eastern elongation on May 30. At this time it lies 23.1° from the Sun, making it relatively easy to spot in the evening sky as dusk settles over the landscape.

Currently, Mercury is moving out from behind the Sun and swinging toward Earth. From mid-May through the first week of June, Mercury reaches its greatest separation from the Sun, which translates into an increase in altitude above the horizon. During this time, Mercury will appear at least 15° above the western horizon — 19° on May 27 — making this apparition the most favorable of the year.

Spotting much-brighter Venus first will help you find Mercury because Venus hovers above and to the left of Mercury during most of the month. On the 30th, Mercury lies near the bright star Castor in Gemini.

No matter when you go out to look for Mercury, you'll need to do it as soon after sunset as possible. You will also need to find an observing site with a clear, flat northwest horizon. A pair of binoculars will also help. Look first with binoculars and then switch to the eye alone. If you follow the planet telescopically, you should be able to watch its phase change from gibbous early in the month to "first quarter" and, as it sinks back toward the horizon in early June, a fat crescent. But by then, viewing Mercury will be more of a challenge.

Mercury Rises into the Evening Sky
Looking west-northwest, shortly after twilight begins



THE STARRY SKY

by Deborah Byrd

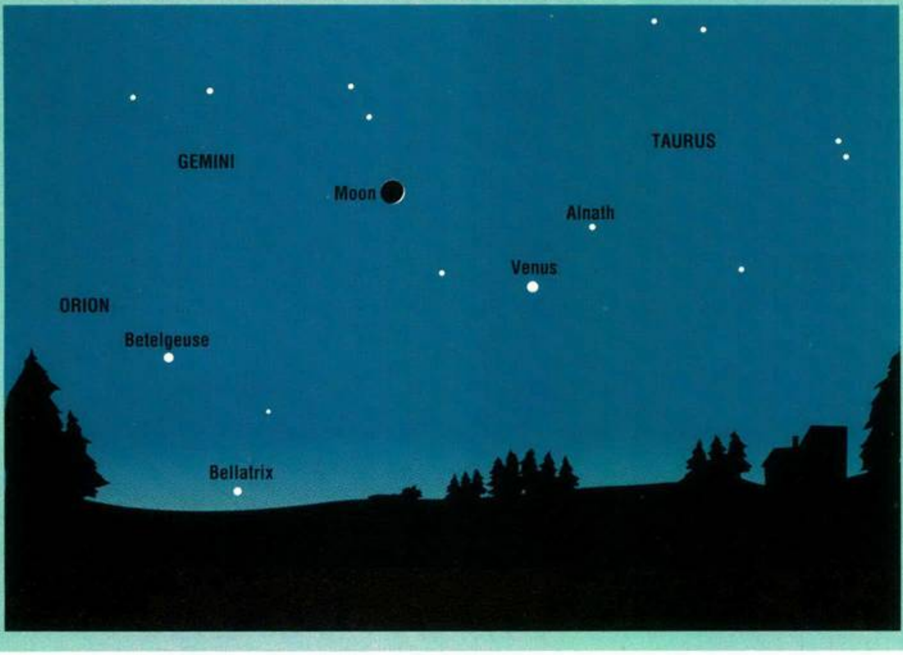
One of the most famous and most ancient constellations is Ursa Major, the Great Bear. Anyone who ventures outside in the early evening this month can see its Big Dipper asterism spreading across the northern sky.

Some backyard astronomers say they cannot see a bear in Ursa Major, and yet legends from many different cultures attach these stars to the lore of a mythical bear. The bowl of the Big Dipper forms the Bear's stomach. The handle represents the Bear's tail. Under a dark sky, you can see front claws of the Bear in the stars Iota and Kappa and back claws in Mu and Lambda. I'll never forget standing outside under a dark West Texas sky one spring evening and suddenly seeing the pattern of the Bear as these stars ascended in the northeast. The bear pattern exists, at least for those fortunate enough to have a dark sky and an active imagination.

The Moon Meets Venus

Go out right after sunset on May 12 and scan the western horizon for the young Moon and the planet Venus. The pair will be hanging out together about 15° above the horizon in the bright twilight. Venus will be to the lower right, or northeast, of the Moon, which appears as just a slim thread of light. Get away from a cluttered horizon and, if you have them, use binoculars to zoom in on the region. The contrast gain will help you locate the feeble Moon. Venus, however, should be more apparent.

The next night, the Moon will be above and left of Venus and not quite as close. It should still be a compelling sight, though, with the Moon a more prominent but still narrow crescent.



Our best known legend about Ursa Major comes from Greek mythology. According to this legend, the king of the gods, Zeus, fell in love with a beautiful woman named Callisto. When Zeus' wife Hera learned of the affair, she changed Callisto into a bear. This bear roamed the forest until one day she happened upon a young and handsome hunter, whom she recognized as her own son, Arcas. Callisto raised up on her hind legs to embrace her child, but Arcas saw only a bear and raised his spear. In the nick of time, Zeus intervened, changing Arcas into a bear. Then he grasped Callisto and her son by their tails and flung them into the sky, to become our constellations of the large and small bears. This explains why the celestial bears have such long tails, in contrast to their earthly counterparts.

Some North American Indian tribes saw things differently. They also pictured bears in Ursa Major and the nearby constellation Ursa Minor, as evidenced by the names frequently used to describe them, Okuri and Paukunawa — both meaning "bear." But in Iroquois mythology, all bears once had long tails. The earthly bear lost its tail attempting to show it off, using the tail to fish through a hole in an iced-over lake. The bear's tail froze and fell off, and now all Earthbound bears mimic this ancient bear with its stumpy tail.

A Blackfoot Indian legend tells of an elder daughter of a large family. The daughter fell in love with a grizzly bear. Her father was furious and ordered her brothers to kill the bear. But this was a magical bear, and before the bear died he gave some of his magic to his bride. She then turned herself into a grizzly bear, and in retaliation she destroyed her entire village, killing her mother and father. She began chasing her eight brothers and sisters, but one brother had magic of his own. He shot an arrow into the sky, and instantly all eight children followed it to become stars. The seven oldest children became the seven stars forming the Big Dipper. The youngest child was frightened, and she can be seen as the dim star Alcor, huddling close to the star Mizar.

The association of these northern stars with a bear is so pervasive that it spawned our name for a major region on Earth. The Greek word for bear was *arktos*, from which springs our word arctic.

David Burt

May 30, Mercury reaches greatest elongation, 23° from the Sun. It then shines at magnitude 0.5 and is easily visible to the lower right of an even brighter object, **Venus**, which shines so bright you can't miss it in the west after sunset. It brightens to magnitude –4.0 by month's end. On May 12 the Moon passes brilliant Venus.

The stars we normally associate with the evening sky in winter are still descending in the west behind Venus this month. The planet starts out near Aldebaran, the fiery eye of the Bull in the constellation Taurus. Aldebaran is a red star, shining at magnitude 0.9 from a distance of about 60 light-years. It lies about 6° to the left of Venus when this month begins.

Another red star lies farther to the left of Venus: Betelguese in the constellation Orion. It shines at magnitude 0.5 from a much greater distance of about 540 light-years. And this month Venus closely approaches a 3rd-magnitude star, Epsilon Geminorum, which lies only 0.4° from Venus on May 28.

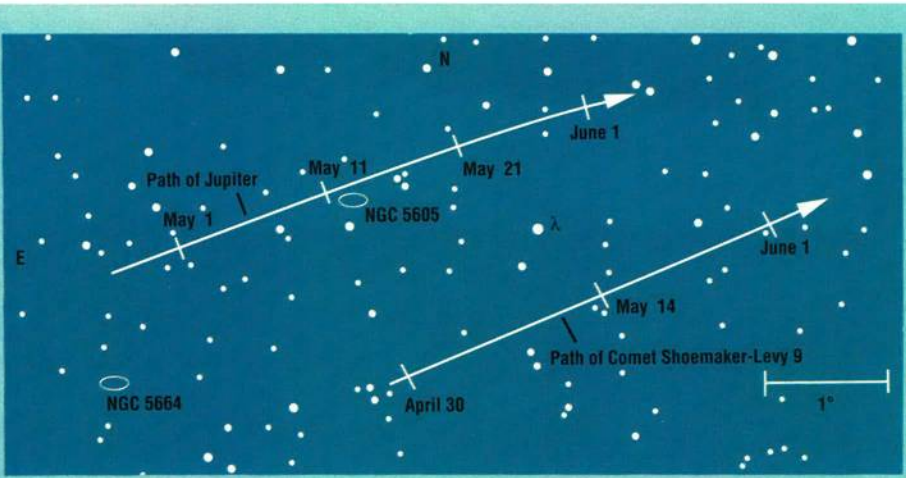
While Venus shines in the west after sunset, its counterpart in brilliance — the second brightest planet, **Jupiter** — shines in the eastern sky. The planet reached opposition at the end of April and is now located in the constellation Libra. Jupiter has reached its peak brightness for the year at magnitude –2.5. It now measures nearly 45" across its equator.

Pluto also resides in Libra, rising not long after Jupiter. The dim, distant planet reaches opposition, a point opposite the Sun in our sky, on May 17. While this month offers the best chance to observe Pluto this year, remember that it glows dimly at magnitude 13.7 and cannot be seen in a telescope smaller than 8 inches in aperture. To search for Pluto, see "Take the Pluto Challenge" (page 88), which provides detailed finder maps for locating the distant world.

Uranus and **Neptune** rise together around midnight when the month begins and earlier as the month wanes. They both lie in the constellation Sagittarius. Uranus shines at magnitude 5.7 and Neptune at 7.9. In July Earth passes between the Sun and these gas giants.

Early this month the Ringed Planet **Saturn** rises along with the stars of Aquarius the Water Bearer around 3 a.m. local time. If you venture out before dawn you'll see the magnitude –1.1 glow of Saturn low in the southeastern sky. On May 4 and 5 watch the Moon pass Saturn in the early morning sky.

Mars floats below and left of Saturn in the eastern predawn sky. The Red Planet passes from Pisces into Aries this month and is rather difficult to spot near the horizon at dawn. The planet shines at magnitude 1.2, which is bright enough that you may spot the planet on May 7, when it lies to the lower left of the Moon. If you venture out to see Mars, you can watch as dawn's light washes away the planet's light and birds begin their morning songs. ☐



Comet Shoemaker-Levy 9 and Jupiter

Comet Shoemaker-Levy 9 has brightened to magnitude 13.5, theoretically within the light grasp of telescopes 10 inches and larger. But the comet's feeble light is still not obvious by any means. Because the comet's light is spread out into an area larger than a point, its surface brightness will be low.

Spotting this challenging object either with the eyes, photography, or a CCD-imaging camera will become increasingly fascinating as the clock runs out for it. By mid-July the comet's fragmented pieces will collide with Jupiter in the first-ever such event that can be observed by astronomers.

Late this month Shoemaker-Levy 9 and Jupiter will move into Virgo. Jupiter is low in the southeast at sunset (Jupiter is just past opposition) and lies due south at midnight. The comet lies about 2° below and to the right (southwest) of Jupiter. If you plot Jupiter's motion along with that of the comet just for the month of May (using the positions given in the above table), it's clear the two bodies are on a collision course. By late June, both comet and planet change their westerly motion and turn back toward the east in the sky heading for their fateful rendezvous.

H. A. Weaver and T. E. Smith, STScI/NASA

HOW TO FIND SHOEMAKER-LEVY 9

On this date	Offset from Jupiter	
	West in R.A.	South in Dec.
May 2	7m45s	1°8'18"
May 8	7m25s	1°5'6"
May 14	7m 3s	1°1'43"
May 20	6m39s	58'9"
May 26	6m12s	54'26"
June 1	5m44s	50'36"

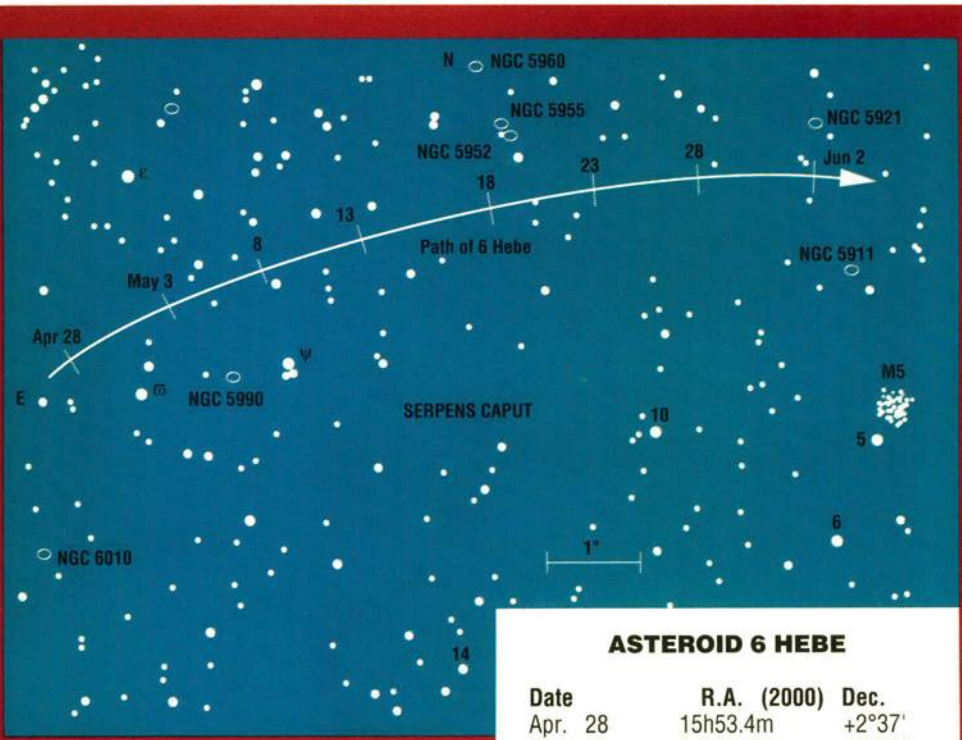
Deborah Byrd produces the monthly "Earth and Sky" radio program. Jeff Kanipe is editor of Star Date.

View Asteroid 6 Hebe

Asteroid 6 Hebe, now cutting through Serpens Caput, the western appendage of Ophiuchus, reaches its peak magnitude (9.8) on May 8. The asteroid lies opposite the Sun in the sky on May 17. As you read this Hebe is making its way into the inner solar system, something it does every 3.7 years.

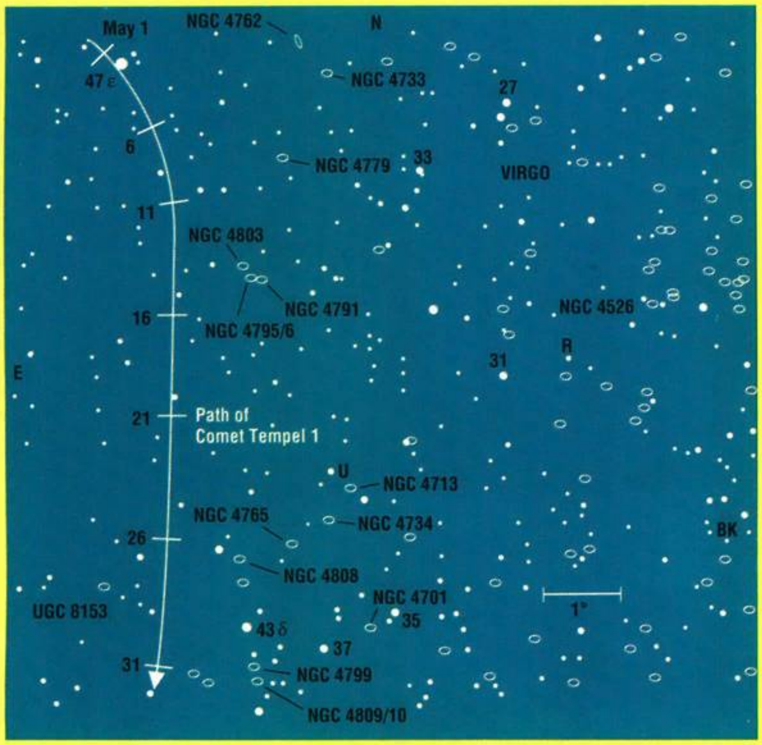
As May begins, Hebe has just passed between Epsilon and Omega Serpentis and is heading almost due west. When it reaches peak brightness, Hebe lies 2½° southwest of Alpha Serpentis. Be careful to pick it out from the busy starfield surrounding it.

To identify this minor planet, you'll need at least a 3-inch telescope and an eyepiece with a field of view of at least a degree. Center the field on the search area using the finder chart above and carefully sketch the position of each star you see. Come back a night or two later, recenter on the same field, and make your sketch again. Now compare the two charts — the "star" that has shifted position with respect to the background stars is Hebe.


N
NGC 5960
NGC 5955
NGC 5952
NGC 5921
Jun 2
28
23
18
13
8
May 3
Apr 28
Path of 6 Hebe
NGC 5911
ε
ψ
ϖ
NGC 5990
SERPENS CAPUT
10
M5
5
E
NGC 6010
1°
6
14

ASTEROID 6 HEBE

Date	R.A. (2000)	Dec.
Apr. 28	15h53.4m	+2°37'
May 3	15h49.4m	+3°06'
May 8	15h45.1m	+3°31'
May 13	15h40.6m	+3°52'
May 18	15h35.9m	+4°08'
May 23	15h31.3m	+4°19'
May 28	15h26.7m	+4°25'
Jun. 2	15h22.5m	+4°24'


May 1
NGC 4762
N
47 ε
NGC 4733
27
6
NGC 4779
33
VIRGO
11
NGC 4803
NGC 4791
NGC 4526
16
NGC 4795/6
31
R
E
21
Path of Comet Tempel 1
U
NGC 4713
NGC 4765
NGC 4734
BK
26
NGC 4808
NGC 4701
35
UGC 8153
43 δ
37
1°
31
NGC 4799
NGC 4809/10

Comet Tempel 1 Brightens

When encountered last month, periodic Comet Tempel 1 was a faint smudge moving slowly through southern Virgo. Tempel 1 still moves through Virgo and is now brightening considerably as it dives south, where it is expected to peak at magnitude 9 in early June. Tempel 1 will be the third-brightest of the predicted comets this year, a couple of magnitudes behind the peaks of Encke and Borrelly. Tempel 1 makes its closest approach to Earth on May 5.

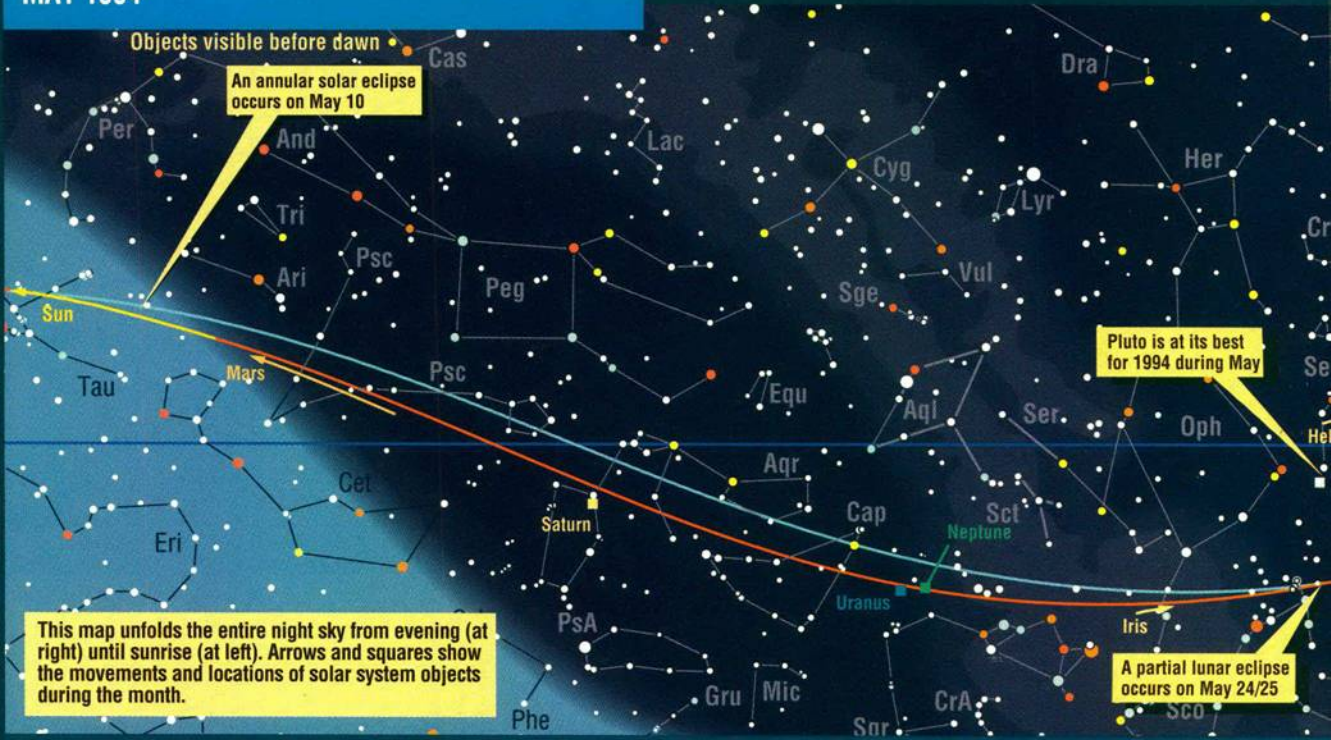
This month, look for Tempel 1 masquerading as an elliptical galaxy just southeast of the main aggregate of the Virgo cluster. On the 19th, the comet lies 2½° northwest of the 4th-magnitude star Delta Virginis. Ten days later it shines near peak brightness and lies just southeast of that star.

COMET TEMPEL 1

Date	R.A.(2000)	Dec.
May 1	13h03.3m	+11°06'
May 6	13h00.4m	+10°11'
May 11	12h58.4m	+9°03'
May 16	12h57.3m	+7°45'
May 21	12h57.3m	+6°17'
May 26	12h58.4m	+4°41'
May 31	13h00.5m	+2°58'

SKY ALMANAC

MAY 1994


Cas
Per
And
Tri
Ari
Psc
Peg
Lac
Cyg
Lyr
Dra
Her
Cr
Sge
Vul
Sun
Mars
Tau
Psc
Equ
Aql
Ser
Oph
Se
Hel
Cet
Aqr
Cap
Sct
Neptune
Uranus
Saturn
Eri
PsA
Iris
Gru
Mic
CrA
Sgr
Sco
Phe

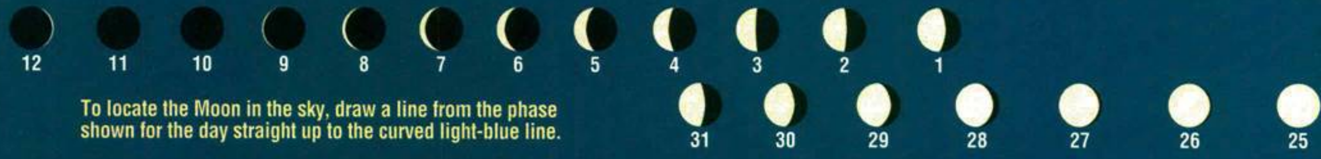
Objects visible before dawn

An annular solar eclipse occurs on May 10

Pluto is at its best for 1994 during May

A partial lunar eclipse occurs on May 24/25

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.


12
11
10
9
8
7
6
5
4
3
2
1
31
30
29
28
27
26
25

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

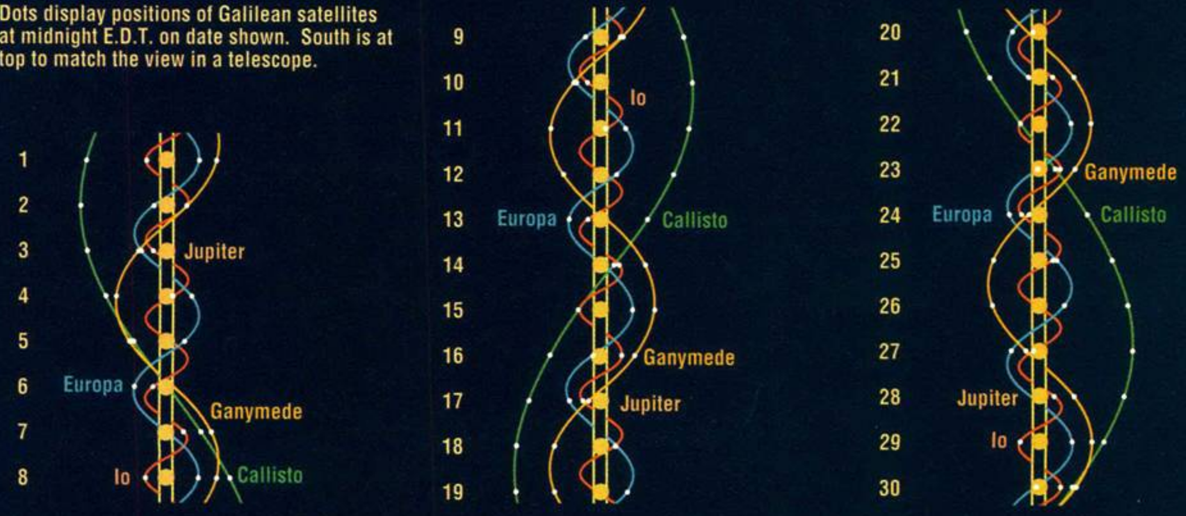
10"

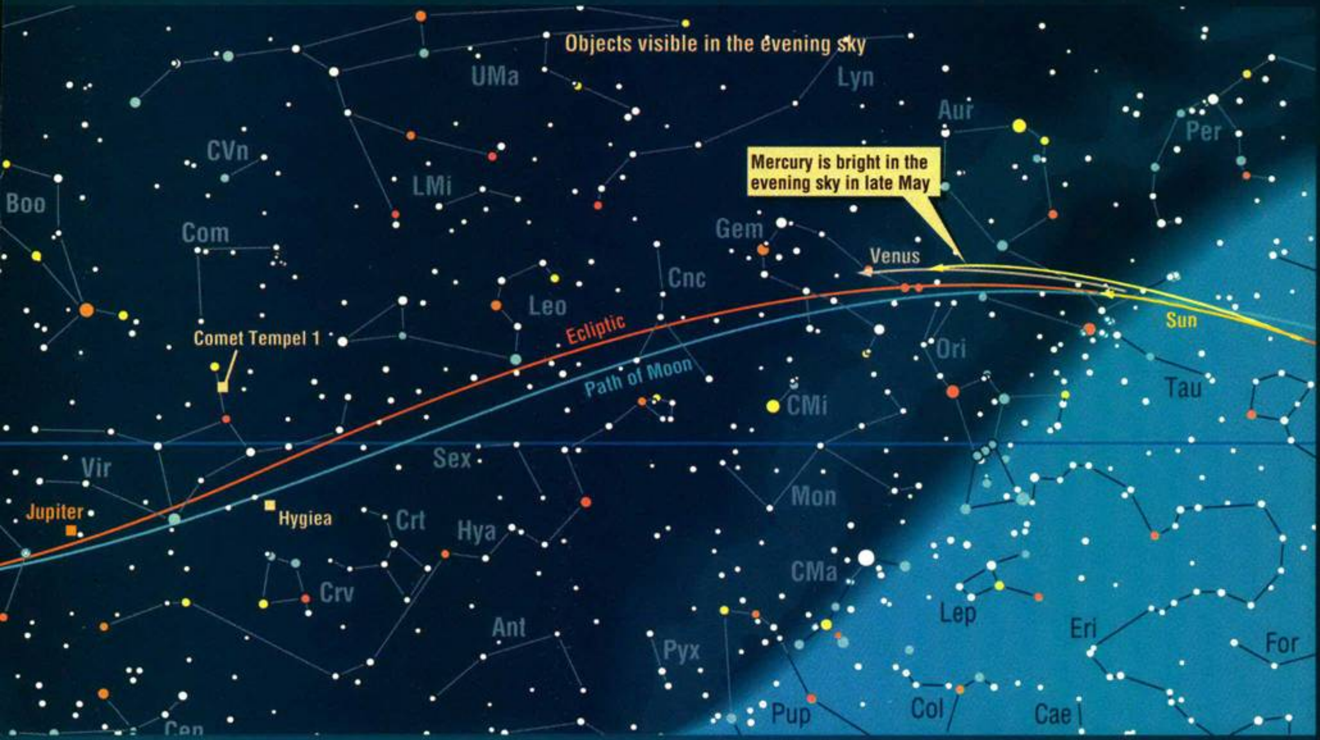
S
W E
N

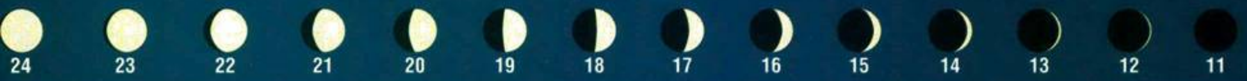
PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS
Date	May 15	May 31	May 1	May 31	May 15
Magnitude	−0.9	0.6	−3.9	−4.0	1.2
Angular Size	6.9"	8.3"	11.2"	12.6"	4.3"
Illumination	76% 	35% 	90% 	83% 	96%
Distance (AU) from Earth	1.141	0.811	1.485	1.321	2.163
Distance (AU) from Sun	0.329	0.416	0.719	0.719	1.393
Right Ascension (2000.0)	4h32.1m	6h10.5m	4h14.9m	6h52.4m	1h27.4m
Declination (2000.0)	+23°55'	+25°09'	+21°59'	+24°42'	+8°13'

JUPITER'S MOONS

Dots display positions of Galilean satellites at midnight E.D.T. on date shown. South is at top to match the view in a telescope.




Objects visible in the evening sky
UMa
Lyn
Aur
Per
CVn
LMi
Boo
Com
Mercury is bright in the evening sky in late May
Gem
Venus
Cnc
Leo
Sun
Ecliptic
Comet Tempel 1
Ori
Path of Moon
Tau
CMi
Sex
Vir
Jupiter
Hygiea
Crt
Hya
Mon
Crv
CMa
Lep
Eri
For
Ant
Pyx
Pup
Col
Cae
Cen


24
23
22
21
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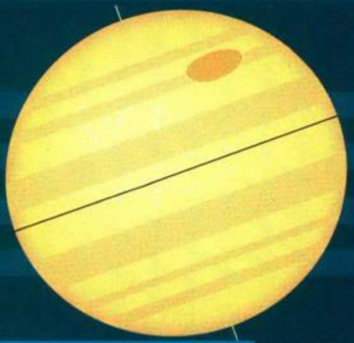
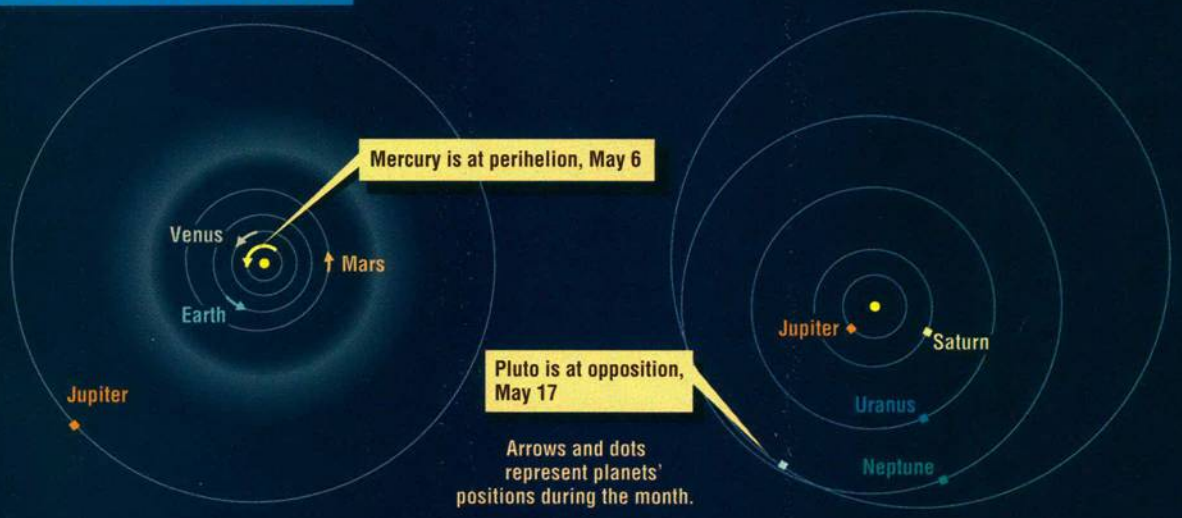
13
12
11



JUPITER	JUPITER	URANUS	NEPTUNE	PLUTO
May 15	May 15	May 15	May 15	May 15
−2.5	1.1	5.7	7.9	13.7
44.3"	16.6"	3.7"	2.3"	0.1"
100%	100%	100%	100%	100%
4.450	9.995	19.165	29.650	28.801
5.428	9.744	19.654	30.178	29.780
14h24.2m	22h52.9m	19h53.5m	19h39.9m	15h51.1m
−12°52'	−8°52'	−21°24'	−20°50'	−5°23'

THE PLANETS IN THEIR ORBITS


Venus
Mars
Earth
Jupiter
Jupiter
Saturn
Uranus
Neptune

Mercury is at perihelion, May 6

Pluto is at opposition, May 17

Arrows and dots represent planets' positions during the month.

Take the Pluto Challenge

Step up to one of the solar system's most subtle light shows.

by John Shibley

Feel up to testing the limits of your observing skill? Take an ambitious step this spring by following faint Pluto as it creeps through the star-poor reaches of northern Libra. If you've observed naked-eye planets for years, looking for such a faint planet seems like the next logical step.

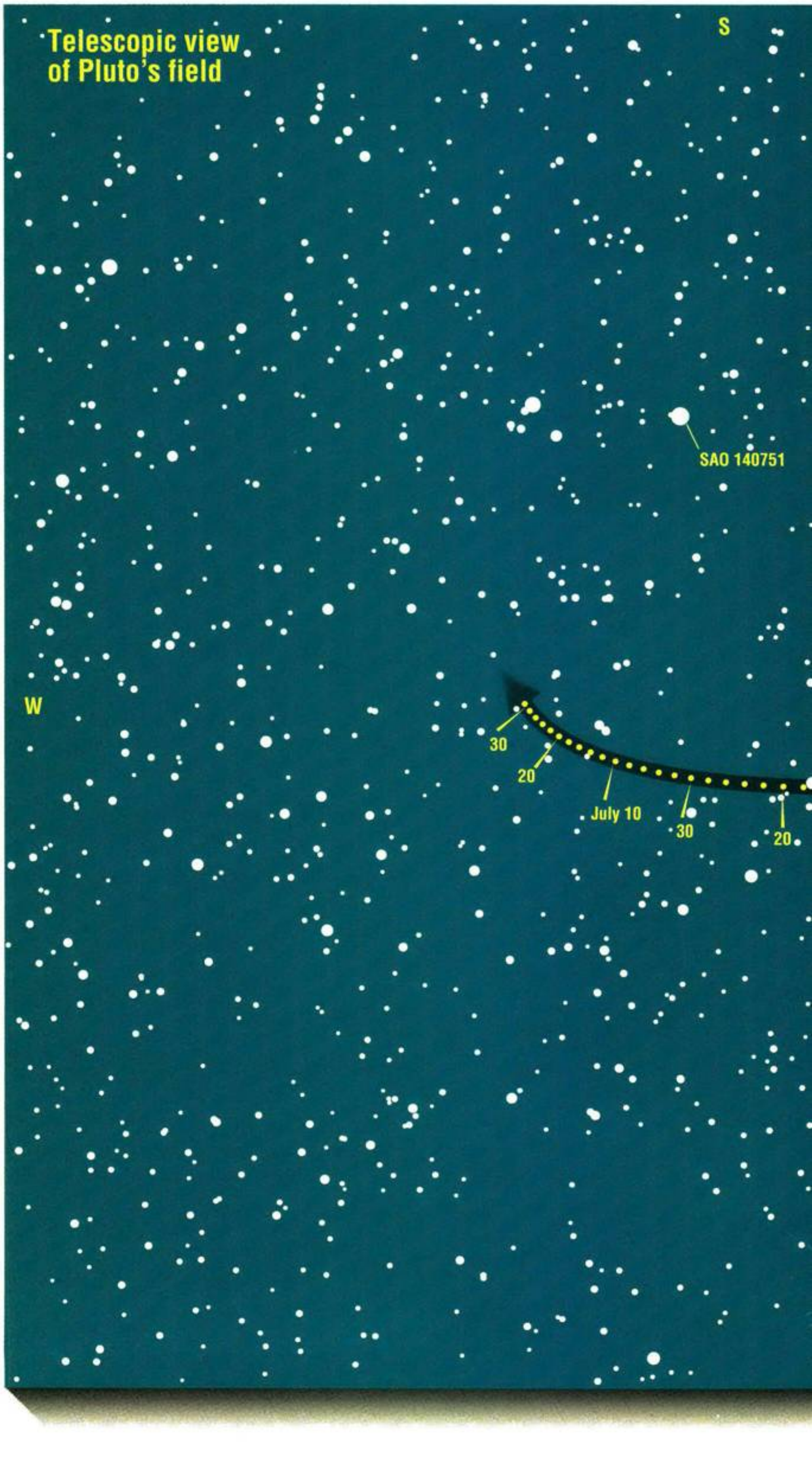
Pluto offers the thrill of finding an icy world at the outskirts of our Sun's neighborhood. What's more, you'll join a select but growing group of amateur astronomers who have spotted this distant planet. Once you have successfully nailed Pluto, you'll be surprised how easily it can be found night after night.

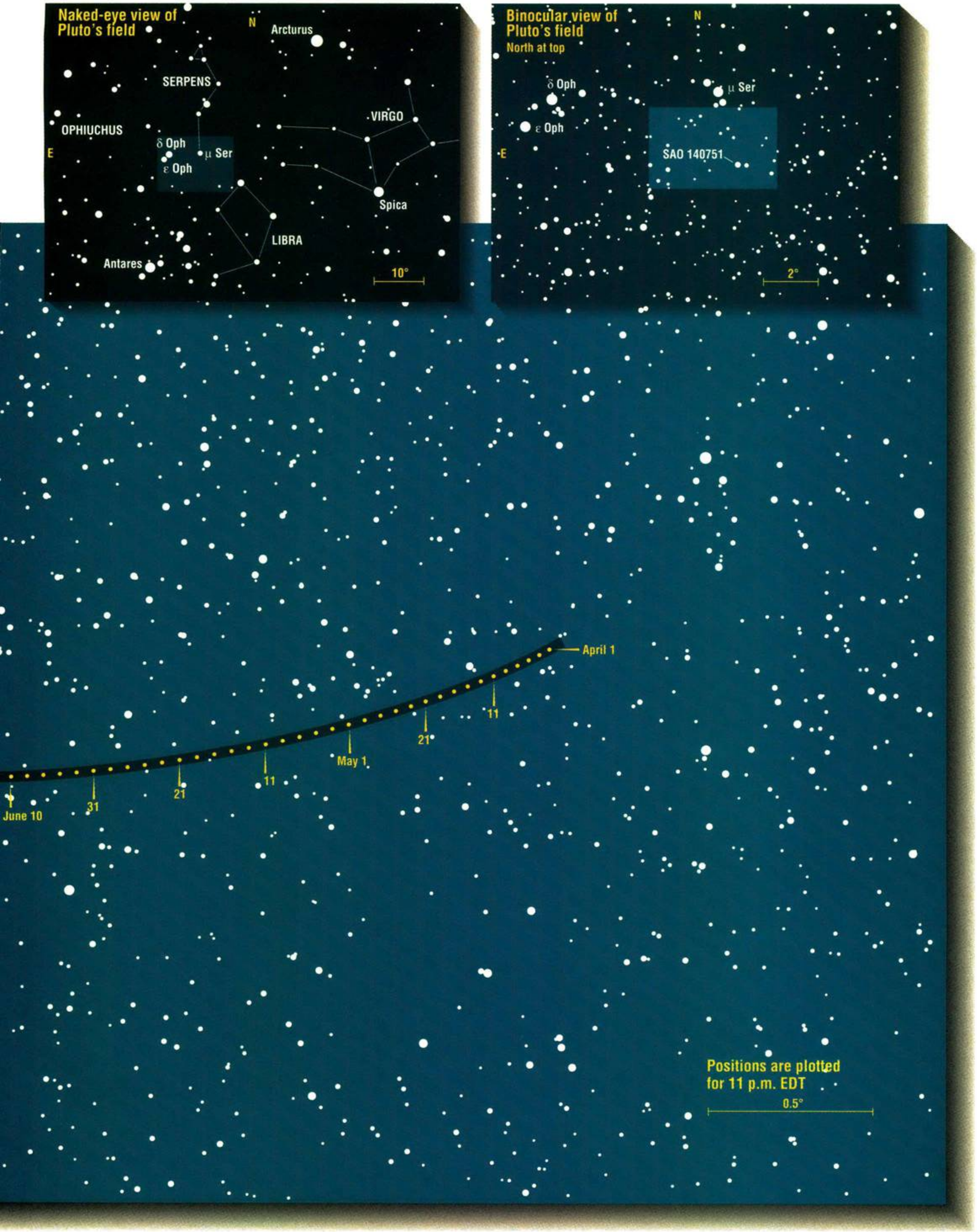
Two factors make Pluto such a challenging object: its size and distance from Earth. At only 1,500 miles in diameter, Pluto has the honor of being our solar system's smallest planet. On top of its tiny size, Pluto is astronishly far away; its light takes about four hours, traveling at 186,000 miles a second, to reach Earth. And this is when we are closest to Pluto (3.5 billion miles) during opposition.

This year Pluto reaches opposition on the evening of May 17th, when Earth lies between it and the Sun. But even then, Pluto glows at only magnitude 13.7, requiring at least an 8-inch telescope to glean. Even through larger scopes it will always look like a faint star in the eyepiece, never showing a disk.

Before going for big game, it's important to make sure your equipment is in order. Check that your optics are clean and properly aligned. Select an observing site away from city lights and from heat given off by concrete streets and roofs. Buildings, parking lots and the like have absorbed sunlight all day. Come evening, they are sources of bubbly pockets of rising air, making it tough to get decent-looking star images through the eyepiece, much less a glance at faint Pluto.

Don't forget to take into account another Pluto-hunting hurdle: the Moon. When there's a bright Moon in the sky, it washes out faint stars and dim objects like Pluto. With its built-in lunar phase


Telescopic view of Pluto's field



Naked-eye view of Pluto's field

N
Arcturus
SERPENS
VIRGO
OPHIUCHUS
δ Oph
μ Ser
ε Oph
E
Spica
LIBRA
Antares
10°

Binocular view of Pluto's field

North at top

N
δ Oph
μ Ser
ε Oph
E
SAO 140751
2°
April 1
11
21
May 1
11
21
31
June 10
0.5°

Positions are plotted for 11 p.m. EDT

chart, ASTRONOMY's Sky Almanac ecliptic chart will help you determine when it's best to observe.

Once you've selected a moonless evening and found a suitable observing site, it's time to begin the search for Pluto. To do that, it's handy to have a road map. The accompanying star charts provide three views of Pluto's area: naked eye, binocular, and telescopic.

The naked-eye chart includes parts of Virgo, Libra, Scorpius, Ophiuchus and Serpens. One object you'll probably see in the sky that's not included on the naked-eye map is Jupiter, which appears as a bright white "star" between Libra and Virgo. The box on this chart shows the area where Pluto resides and conveys the coverage of the next chart in our sequence: the binocular chart.

This chart shows a smaller portion of sky as it might look through binoculars or a finder scope. Note that it includes stars fainter than what can be seen with the unaided eye.

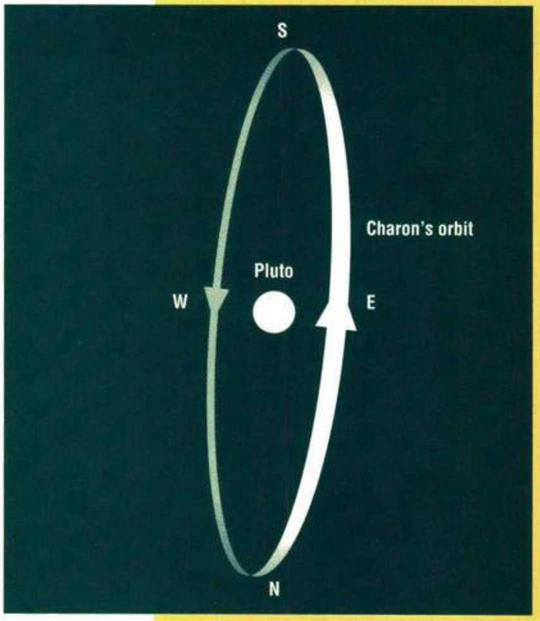
The final chart in our sequence, the telescopic chart, shows stars that will play an important role in pinpointing Pluto. Covering about four degrees of sky, this map shows stars down to magnitude 14.5. Note that south is at the top, and west is at left, a perspective that most telescopes present.

Take your Pluto search slow; don't look for the planet on your first outing. Remember that it's faint and tough to distinguish from the multitudes of other faint nearby stars. Instead, using the telescopic finder chart and your scope at low power (40x to 60x), identifiy bright star patterns that lie along Pluto's projected path. Find bright reference stars you can star-hop away from and toward while scanning through the area.

Another hint: Examine Pluto's path on the telescopic chart, noting the dates when it will pass close to star patterns. Using a nearby star or triangle of stars for reference will help you follow Pluto's motion from night to night.

On the evening you attempt to locate Pluto, note its predicted position on a photocopy of the telescopic chart. At your telescope's eyepiece, starting at low power (40x to 50x), locate the field where Pluto should be that evening. Once you've narrowed down where Pluto is, boost your magnification up to about 100x. Compare the view in your eyepiece with what's on your copy of the telescopic finder chart, eliminating any obvious stars. At this stage, you should have a candidate for Pluto. Confirm your hunch by using Pluto to form patterns with nearby stars on the finder chart. If you still aren't sure of the planet's identity, increase magnification slightly and make a rough sketch, circling your candidate Pluto. Return to the star field within the next couple of nights; anything that's moved is the planet Pluto.

Finding Pluto may seem like a lot of work. But for you, the astronomer, it'll mean something more. For a brief moment your telescope will serve as a bridge between worlds. The light that left Pluto four hours ago will tickle the rods in your eye from halfway across our solar system. ◪



Take the Charon Challenge?

With a large (15- to 20-inch) telescope working at high magnification you just might, with a lot of luck, detect Pluto's moon Charon. On paper it seems possible. At greatest elongation Charon appears about 1" from Pluto, so it would seem likely that given perfect (albeit rare) half-an-arcsecond seeing conditions observers should be able to detect a 1" lopsidedness in Pluto's shape. And with the powerful manipulation powers found in image-processing programs, the odds of a backyard astronomer's landing a CCD image similar to the photo taken in 1978 when Charon was discovered indeed seems promising.

Bear in mind that all the variables — atmospheric seeing, Charon's elongation, an optically fine-tuned telescope — will have to be working for you. Don't be surprised if no amount of careful scrutiny reveals a lopsided Pluto.

But if you decide to take the Charon challenge, use the table of predicted Charon elongations, take your best shot, and submit observations to ASTRONOMY.

Charon elongation times (in Eastern Time). Northern elongation dates are in **bold**.

April	**3**	**2:18 p.m.**
	6	6:48 p.m.
	9	**11:36 p.m.**
	12	4:06 p.m.
	16	**8:54 a.m.**
	19	1:24 p.m.
	22	**6:12 p.m.**
	25	10:42 a.m.
	29	**3:30 a.m.**
May	2	8:00 a.m.
	5	**12:48 p.m.**
	8	5:18 p.m.
	11	**10:06 p.m.**
	15	2:36 a.m.
	18	**7:30 a.m.**
	21	12:00 a.m.
	24	**4:48 p.m.**
	27	9:24 p.m.
	31	**2:06 a.m.**
June	3	6:48 a.m.
	6	**11:24 a.m.**
	9	3:54 p.m.
	12	**8:42 p.m.**
	16	1:12 a.m.
	19	**6:00 a.m.**
	22	10:30 a.m.
	25	**3:18 p.m.**
	28	7:48 p.m.
July	**2**	**12:36 a.m.**
	5	5:06 p.m.
	8	**9:54 a.m.**
	11	2:24 p.m.
	14	**7:18 p.m.**
	17	11:48 p.m.
	21	**4:30 a.m.**
	24	9:00 a.m.
	27	**1:48 p.m.**
	30	6:18 p.m.

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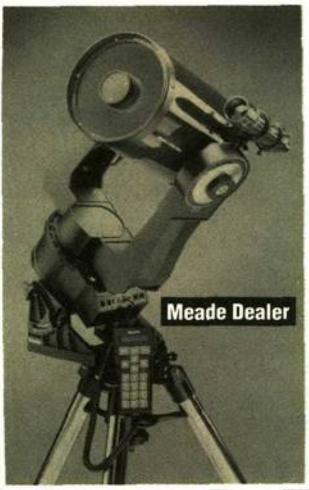

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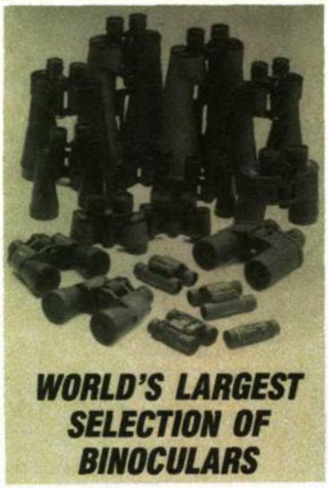
Dual System
H.I.T. Telescope

Parks
Widefield 60

Parks
Jovian-4



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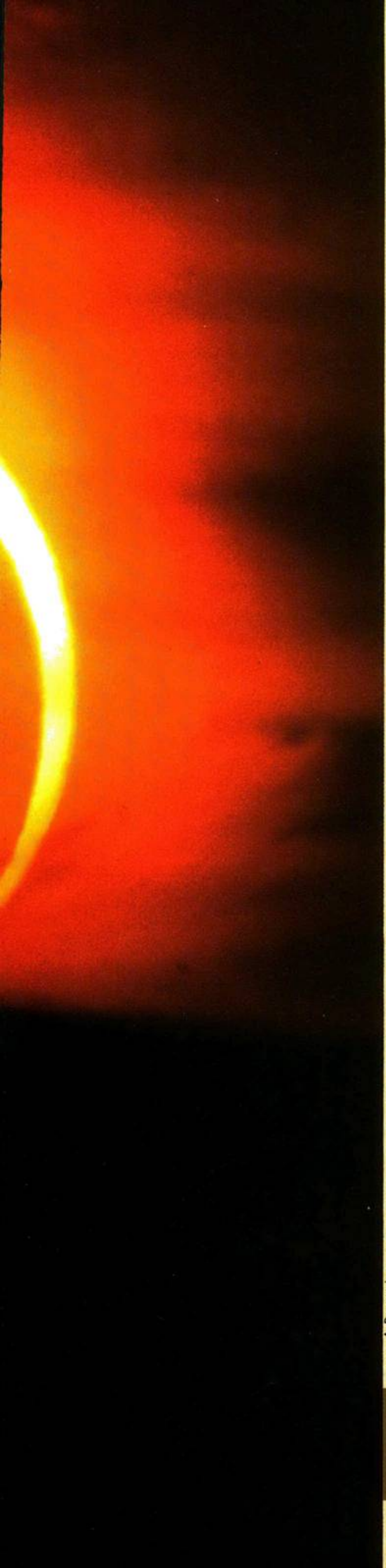
May's RING of FIRE



Mark your calendar for May 10. That's when a spectacular annular eclipse will place a ring of sunlight in the skies over much of North America.

by Richard Talcott

The United States will be the center of the astronomical universe this May as the Moon's shadow races across our country. Millions of people in North America will see an annular eclipse of the Sun without having to leave their backyard. Thousands of others will travel to the path of annularity to see the Moon pass directly in front of the Sun. Because the Moon isn't quite big enough to cover the whole Sun, observers will see a ring of sunlight at mid-eclipse.

The Moon's shadow first touches Earth at sunrise well out in the Pacific Ocean and then heads east-northeast until making landfall on the west coast of Baja California. The shadow's path traverses the central part of the Baja Peninsula, where the annular phase lasts 5 minutes 28 seconds and the Sun appears 40° above the eastern horizon.

The shadow then passes over the Gulf of California and strikes mainland Mexico near the town of Bahía Kino. It next crosses northwestern Mexico before reaching the southwestern United States. The southeastern tip of Arizona, southern New Mexico, and western and northern Texas all see an annular eclipse in the mid-to-late morning.

From the Texas Panhandle, the Moon's shadow heads northeast through central Oklahoma, southeastern Kansas, and central Missouri, passing over Oklahoma City and St. Louis and just south of Kansas City. From St. Louis, which lies near the southern limit of the path of annularity, the eclipse starts at 11:52 a.m. CDT and lasts 3 minutes 44 seconds with the Sun 65° above the southeastern horizon. That compares with an annular phase lasting over 6 minutes from a point along the center line in Missouri.

Crossing the Mississippi River into Illinois, the path neatly bisects the Land of Lincoln before heading into northern Indiana. Both Chicago and Indianapolis just miss seeing the annular eclipse, though observers there will still witness a partial eclipse that covers 94 percent of the Sun.

Continuing east and slightly north, the path then heads into northern Ohio and southern Michigan. Maximum eclipse occurs just west of Toledo, Ohio, where annularity lasts 6 minutes 14 seconds and the Sun lies 66° above the southern horizon at 1:13 p.m. EDT. At that point the Moon covers just over 94 percent of the Sun's diameter and 89 percent of the Sun's area. All of Lakes Erie and Ontario, as well as their U. S. and Canadian shorelines, lie within the path of annularity, including Detroit, Cleveland, Buffalo, and Toronto.

The track then heads through upstate New York and northern New England, covering almost all of Vermont and New Hampshire and the southern half of Maine. It then leaves the United States and heads back into Canada, grazing the southern coast of New Brunswick before encompassing most of Nova Scotia. From Halifax, the annular eclipse starts at 2:56 p.m. ADT and lasts 5 minutes 53 seconds with the Sun 55° high in the southwest.

On to Africa

But the eclipse doesn't end in America. After traversing the North Atlantic, the path of annularity once again touches land in the Azores, where the eclipse lasts 5 minutes 10 seconds and the Sun lies 27° high. The path finally reaches the Atlantic coast of Morocco as sunset approaches.

A. Bormanis

THE MOON CREATES A HALO out of the Sun during an annular eclipse, covering the center of the Sun and leaving a brilliant ring of sunlight around the Moon's limb.

Residents of Casablanca will witness an annular eclipse lasting 4 minutes 33 seconds with the Sun poised just 3° above the ocean.

If you don't feel like traveling to see the annular eclipse, you can still see a partial eclipse from anywhere in North America. Nearly half the contiguous United States will have at least 80 percent of the Sun covered at maximum eclipse, and every spot except northwestern Washington state will see at least half the Sun covered. In fact, the only spots in North America that will see less than a 40 percent eclipse are those in Alaska, northwestern Canada, and extreme southern Mexico.

Weather prospects along the eclipse track vary from great in eastern Baja California, western mainland Mexico, and the southwestern United States, to mediocre in the Midwest, Northeast, and Africa. For more details on eclipse weather prospects, see "Sunblock" by Jay Anderson (February 1994).

What to Look for

The eclipse officially gets under way at first contact, when the edge of the Moon's disk first encroaches on the Sun. However, it's not until a moment later, when the Moon's disk covers a perceptible part of the Sun's disk, that you can see the eclipse has actually begun.

The next 30 to 45 minutes is one of seemingly breathless anticipation. If you don't check the Sun occasionally to see that the Moon is making steady progress, you might not be aware that an eclipse is taking place. The signs are few and subtle. Although the sky grows darker, the pace of change is slow and difficult to discern.

After the Sun is about half-covered, a perceptive eye will start to notice changes. Shadows sharpen as the source of light in the sky becomes smaller. By the time the Moon covers about 80 percent of the Sun's disk, the sky is noticeably darker. (Although to a person on the street not aware of the ongoing eclipse, the changes would be easy to miss.) This is a good time to briefly shift your attention from the sky to the ground. Look closely at the sunlight filtering through the leaves of nearby trees and bushes and you'll see hundreds or thousands of tiny images of the crescent Sun. The openings between the leaves serve as pinholes that project images of the eclipsed Sun.

(continued on page 98)

View the Eclipse Safely

The sight of the eclipsed Sun hanging majestically in a clear blue sky is one you won't soon forget. But an annular eclipse brings with it a potential for damaging your eyesight. Viewing a partially eclipsed Sun — even during the annular phase — can seriously injure your eyes in seconds. And there's no warning: The retina has no pain receptors, so the damage happens painlessly, and the visual effects may not appear until hours later.

To avoid these hazards, you can view the partially eclipsed Sun through a high-quality filter that blocks most of the Sun's ultraviolet, visible, and infrared radiation, or project an image of the Sun on a white surface.

Three types of filter work well. An inexpensive, safe filter is a #14 arc-welder's glass (don't use those with lower numbers). Look in the Yellow Pages under "Welding Equipment and Supplies" for a dealer near you.

A Mylar filter or a metal-on-glass filter is great for viewing the eclipse visually or with a telescope and can double as a photographic filter. These filters are available from several companies (look for their ads in ASTRONOMY). When you purchase one, check it for pinholes and other defects by holding it up to a bright light and seeing if any light leaks through.

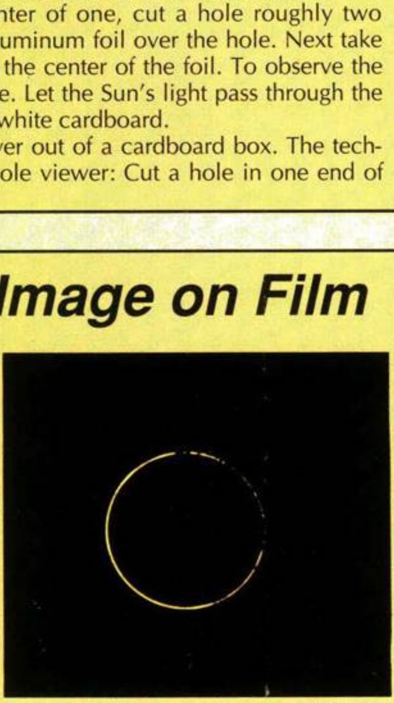
Any other type of filter risks causing serious eye damage. Never use a "Sun filter" that screws into the eyepiece. These can crack under intense sunlight and let through the full power of the Sun. If you have one, throw it away before someone gets hurt using it. Also avoid exposed black-and-white or color film, sunglasses, smoked glass, crossed polarizing filters, black plastic garbage bags, and aluminized Mylar "space blankets," window insulation, or candy wrappers. Although these materials transmit little light, they don't do much to stop the hazardous ultraviolet and infrared radiation.

The safest way to view the eclipse is by projecting an image of the Sun. One method is to create your own pinhole viewer. Start with two pieces of stiff white cardboard and, in the center of one, cut a hole roughly two inches across. Then tape a piece of aluminum foil over the hole. Next take a straight pin and poke a tiny hole in the center of the foil. To observe the eclipse, don't look through the pinhole. Let the Sun's light pass through the pinhole and onto the second piece of white cardboard.

You can also make a pinhole viewer out of a cardboard box. The technique is the same as for the first pinhole viewer: Cut a hole in one end of

Capturing the Image on Film

Many people don't consider an eclipse expedition a success unless they bring home a stunning photograph of the eclipsed Sun. It's not as hard as you might think.

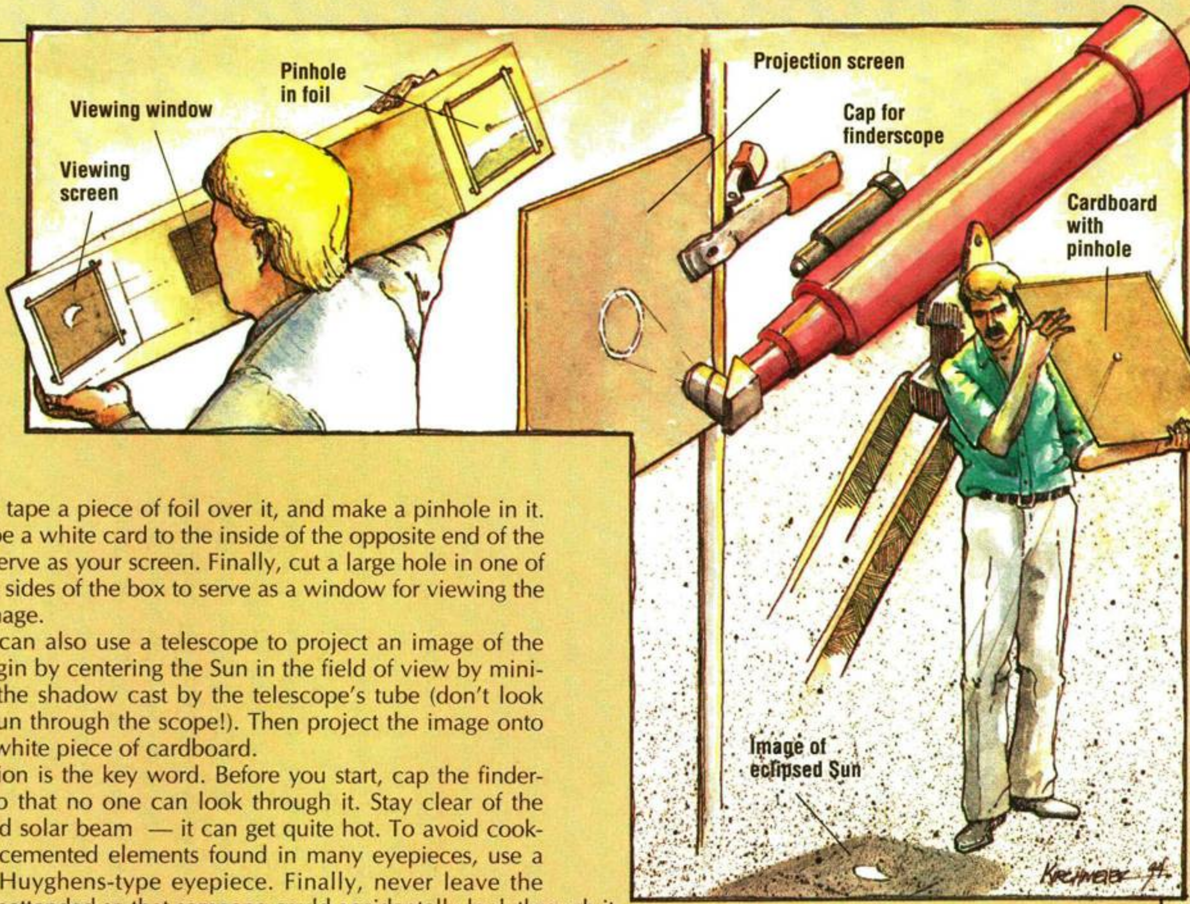


Lyle Fischer

To record an image of the Sun large enough to show details, you'll need a hefty telephoto lens or a telescope you can use as your camera's lens. A 500mm lens will give you an image on film 4.5 mm across, big enough to show some detail when you enlarge it. But a 1,000mm-focal-length telescope will give you a 9mm-wide image that should easily show sunspots being gobbled up by the advancing edge of the Moon.

Because this eclipse is not total, you must filter out almost all of the Sun's intensity. The best solar filters are made of aluminized Mylar or metal-on-glass and fit over the aperture of the telescope or telephoto lens.

Fortunately the Sun will be bright enough that you can use a slow fine-grain film and still keep the exposure times short. A film with an ISO rating of 100 or so will capture sharp detail and retain that detail when enlarged. Good print films include Ektar 125, Kodacolor 100, and Fujicolor 100. For



the box, tape a piece of foil over it, and make a pinhole in it. Next tape a white card to the inside of the opposite end of the box to serve as your screen. Finally, cut a large hole in one of the long sides of the box to serve as a window for viewing the Sun's image.

You can also use a telescope to project an image of the Sun. Begin by centering the Sun in the field of view by minimizing the shadow cast by the telescope's tube (don't look at the Sun through the scope!). Then project the image onto a large white piece of cardboard.

Caution is the key word. Before you start, cap the finderscope so that no one can look through it. Stay clear of the projected solar beam — it can get quite hot. To avoid cooking the cemented elements found in many eyepieces, use a cheap, Huyghens-type eyepiece. Finally, never leave the scope unattended so that someone could accidentally look through it.

And keep your telescope's health in mind too. Don't use a Schmidt-Cassegrain or Maksutov telescope: Heat can damage the secondary mirror. Whatever telescope you use, stop down the aperture to one to two inches to prevent heat from building up. Also periodically let the optics cool by putting the lens cap back on.

Few events can compare with a solar eclipse, but none offers as much chance for injury — to you or your equipment. With a good filter or solar projection, you can witness this breathtaking event and save your eyesight for the next one.

slide film, try Kodachrome 64, Ektachrome 100, or Fujichrome 100.

Because the long focal length you'll be using magnifies the Sun so much, the slightest motion of the camera or lens can noticeably blur the image. That's why a sturdy tripod or telescope mounting is a must for sharp eclipse photos.

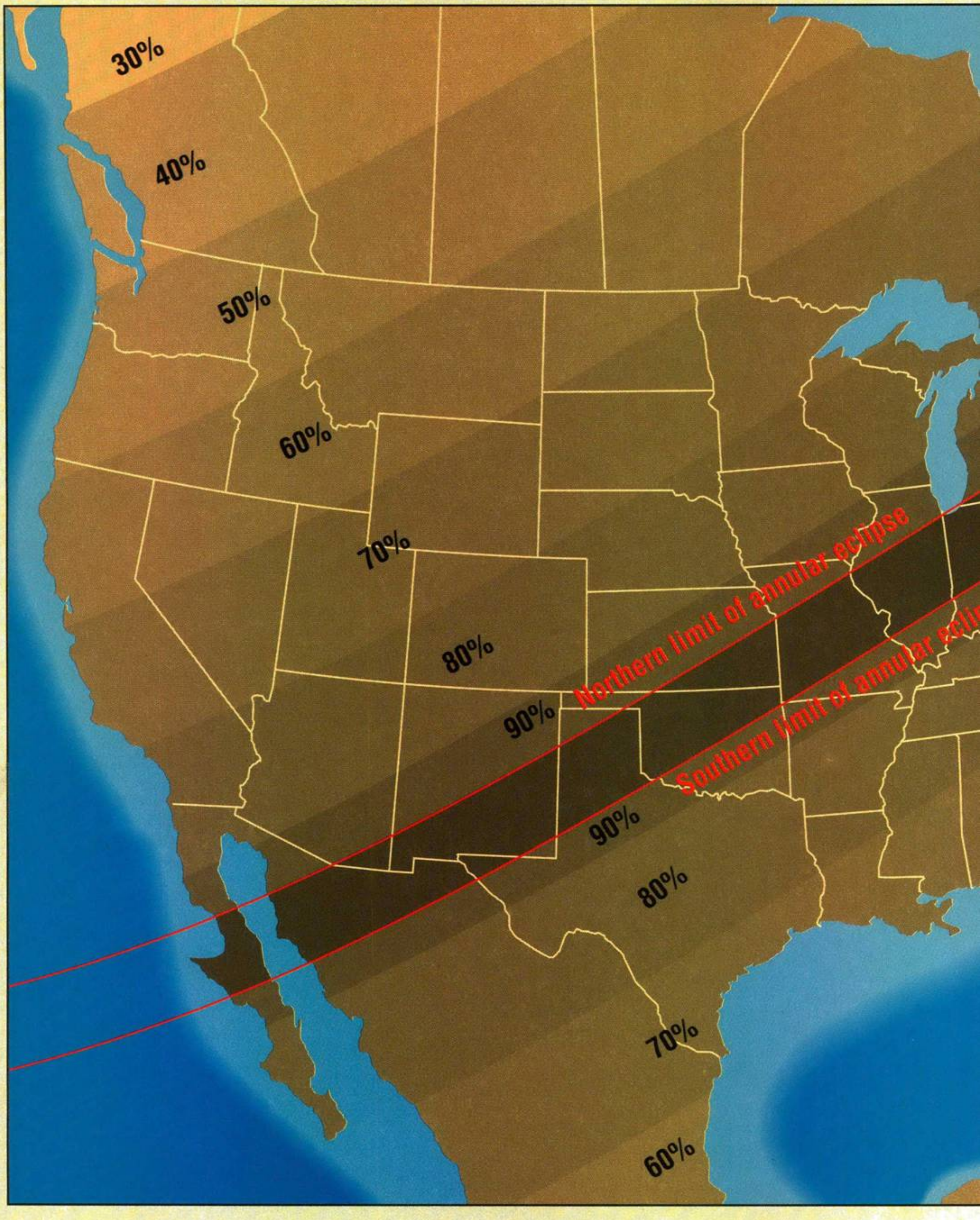
But a sturdy mount by itself won't guarantee rock-steady images. Use a cable release or, even better, use the camera's self-timer (if it has one) to trigger the shutter. And if your camera allows you to lock the mirror out of the way, do so. Fortunately most annular eclipse photos have short-enough exposures that the Sun's motion won't show up on film.

During the partial phases, your exposures will probably run about 1/125 second at f/8 with ISO 100 film. But the exact exposure depends on what filter you use and the sky conditions. To get perfect eclipse photos, make a test run a week or more before eclipse day. With your filter in place, shoot a roll of your chosen film using a wide range of exposures and f/stops. Then get the film developed and see which combination worked best.

On eclipse day, shoot the partial phases using the same exposure and f/stop. (Though bracket your exposures by one or two f/stops or shutter speeds in case sky conditions are different.) As annularity approaches, increase the exposure by one or two stops to compensate for the Sun's limb appearing slightly darker than the rest of the solar disk.

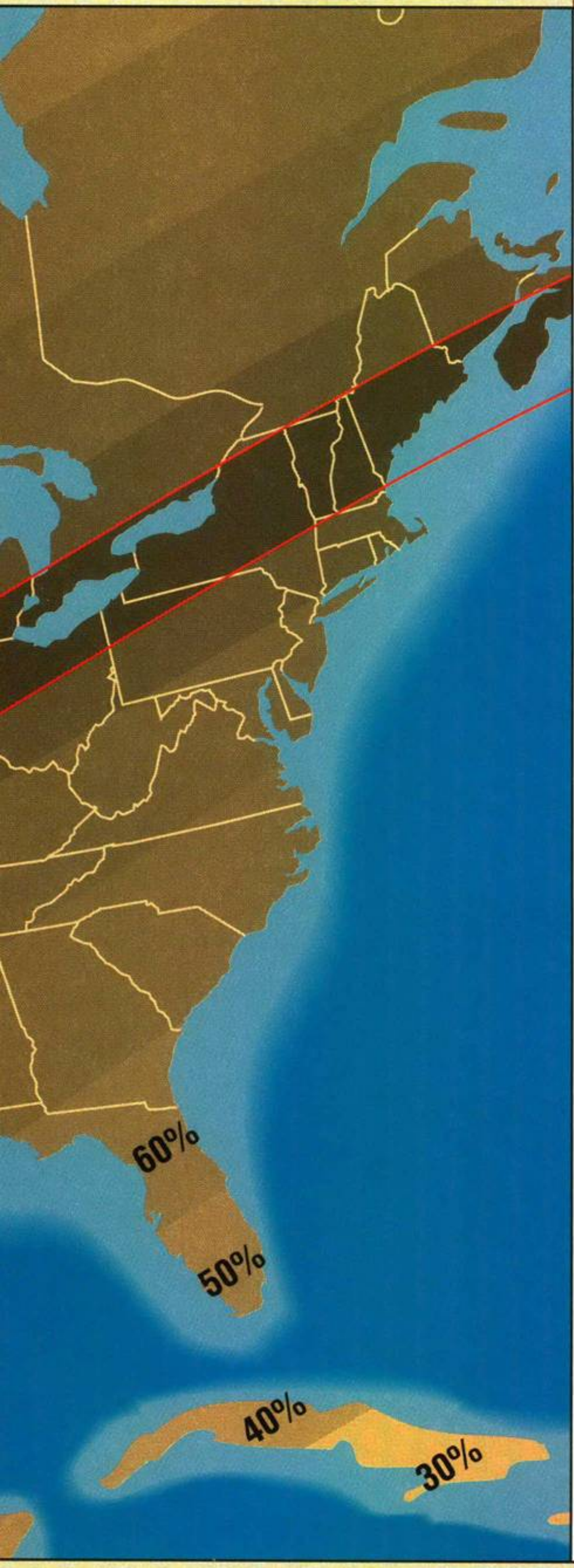
James Glenn Pearson

Cutting a Swath Across North

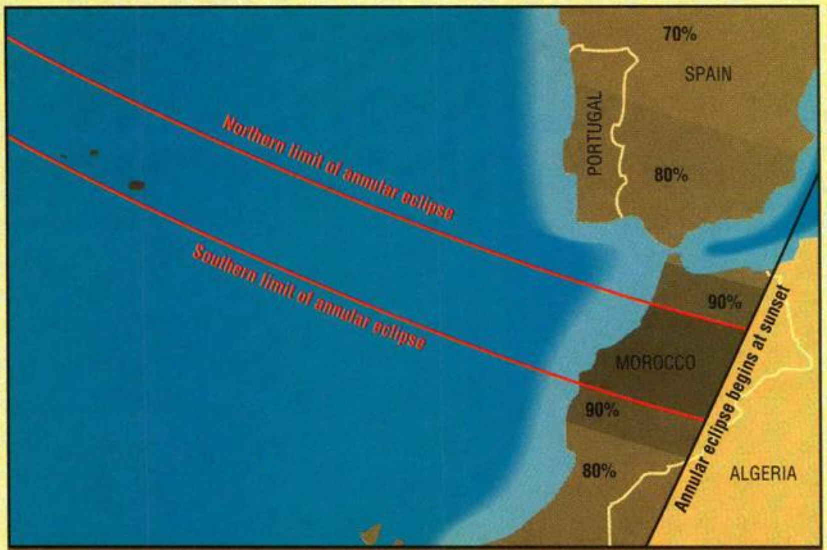

30%
40%
50%
60%
70%
80%
90%
Northern limit of annular eclipse
Southern limit of annular ecli
90%
80%
70%
60%

America

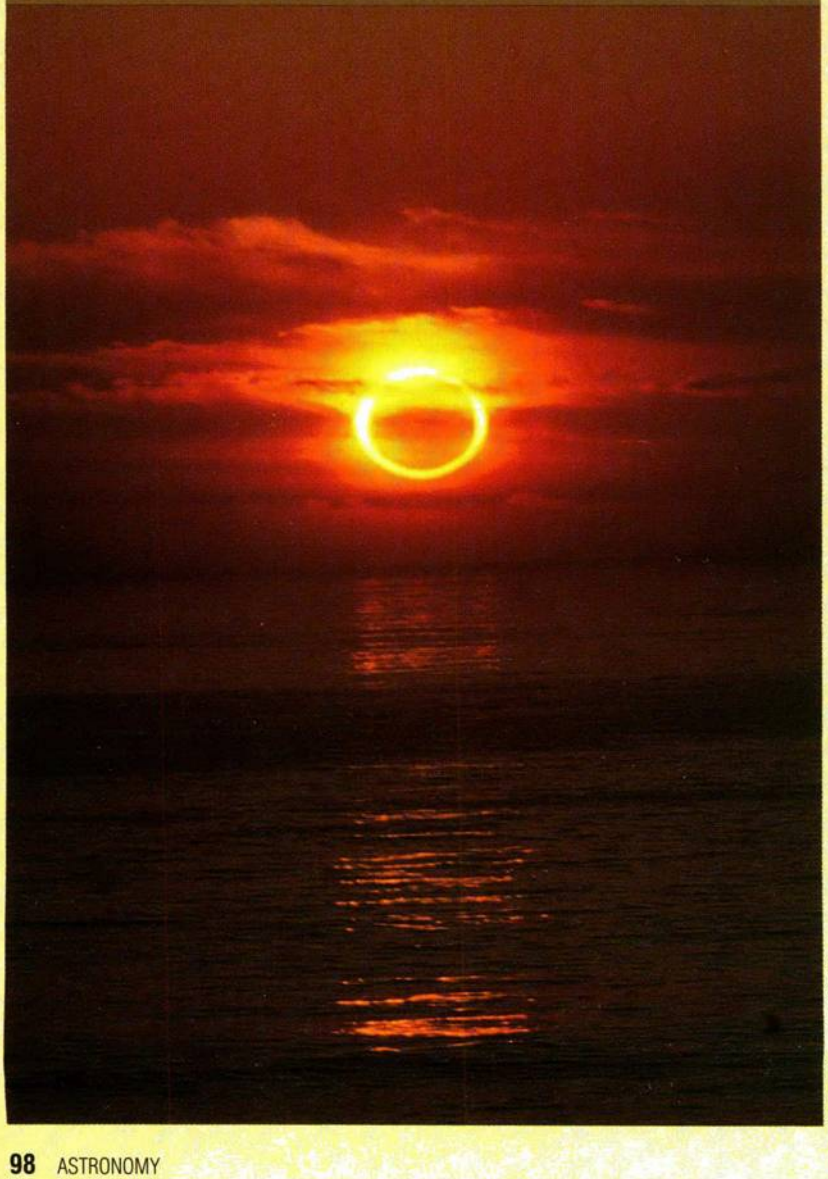
CUTTING ACROSS AMERICA from Baja California to the Canadian Maritimes, the track of May's annular eclipse puts millions of people in position to view the Moon's shadow.



City	Local Time of Max. Eclipse	% Eclipsed	Duration of Annularity
Albany, NY	1:37 p.m.	94%	1m32s
Albuquerque, NM	10:16 a.m.	90%	—
Amarillo, TX	11:24 a.m.	94%	4m36s
Atlanta, GA	1:00 p.m.	77%	—
Baltimore, MD	1:28 p.m.	87%	—
Boston, MA	1:43 p.m.	93%	—
Buffalo, NY	1:25 p.m.	94%	6m11s
Casablanca	6:59 p.m.	93%	4m33s
Chicago, IL	12:04 p.m.	94%	—
Ciudad Juarez	10:10 a.m.	94%	5m38s
Cleveland, OH	1:17 p.m.	94%	4m47s
Concord, NH	1:42 p.m.	94%	4m03s
Dallas, TX	11:29 a.m.	88%	—
Denver, CO	10:28 a.m.	82%	—
Des Moines, IA	11:51 a.m.	89%	—
Detroit, MI	1:15 p.m.	94%	5m19s
El Paso, TX	10:10 a.m.	94%	5m40s
Erie, PA	1:21 p.m.	94%	5m44s
Fort Wayne, IN	12:09 p.m.	94%	6m09s
Halifax, NS	2:59 p.m.	94%	5m53s
Hartford, CT	1:39 p.m.	92%	—
Hermosillo	9:59 a.m.	94%	5m17s
Honolulu, HI	5:56 a.m.	55%	—
Indianapolis, IN	12:05 p.m.	94%	—
Kansas City, MO	11:45 a.m.	94%	—
Las Cruces, NM	10:11 a.m.	94%	5m16s
London, ON	1:20 p.m.	94%	4m44s
Los Angeles, CA	9:00 a.m.	79%	—
Louisville, KY	1:03 p.m.	90%	—
Lubbock, TX	11:21 a.m.	94%	4m38s
Mazatlán	9:53 a.m.	77%	—
Mexico City	10:57 a.m.	59%	—
Miami, FL	1:00 p.m.	52%	—
Milwaukee, WI	12:05 p.m.	91%	—
Minneapolis, MN	11:57 a.m.	82%	—
Montpelier, VT	1:40 p.m.	94%	5m37s
Montreal, QU	1:38 p.m.	92%	—
New Orleans, LA	11:38 a.m.	73%	—
New York, NY	1:36 p.m.	89%	—
Omaha, NE	11:46 a.m.	88%	—
Ottawa, ON	1:33 p.m.	92%	—
Peoria, IL	11:58 a.m.	94%	3m43s
Phoenix, AZ	9:06 a.m.	87%	—
Pittsburgh, PA	1:20 p.m.	92%	—
Portland, ME	1:45 p.m.	94%	5m39s
Portland, OR	9:19 a.m.	54%	—
Providence, RI	1:42 p.m.	91%	—
Richmond, VA	1:24 p.m.	82%	—
St. Louis, MO	11:53 a.m.	94%	3m44s
St. John, NB	2:54 p.m.	94%	3m18s
San Diego, CA	8:59 a.m.	83%	—
San Francisco, CA	9:04 a.m.	68%	—
Seattle, WA	9:23 a.m.	51%	—
Springfield, IL	11:57 a.m.	94%	6m10s
Toledo, OH	1:13 p.m.	94%	6m14s
Toronto, ON	1:24 p.m.	94%	2m54s
Tucson, AZ	9:05 a.m.	91%	—
Tulsa, OK	11:37 a.m.	94%	2m46s
Washington, DC	1:26 p.m.	86%	—
Wichita, KS	11:37 a.m.	94%	3m02s


70%
SPAIN
PORTUGAL
80%
Northern limit of annular eclipse
Southern limit of annular eclipse
90%
MOROCCO
90%
80%
ALGERIA
Annular eclipse begins at sunset

THE ECLIPSED SUN WILL SINK into the ocean as seen from the coast of Morocco around Casablanca (above). A similar view greeted observers in southern California and northern Baja California on January 4, 1992 (below).



Durruty Jesus de Alba M.

Finally, a bit over 90 minutes after the eclipse begins, the Moon's trailing limb moves inside the Sun's disk and annularity begins. For the next six minutes or so — if you observe from near the center line — the Moon will cross the solar disk. If you're near the northern or southern limit of the eclipse track, watch for Baily's Beads near the Moon's limb. These beads are sunlight passing through valleys along the lunar limb; they look much like jewels on a necklace. Baily's Beads won't stand out as much as they do just before a total eclipse because the ring of sunlight brightens the sky significantly, but they still are worth looking for.

Also look for the brightest planet, Venus, during annularity. It lies 28° east of the Sun at eclipse time, and if you block out the light of the Sun with your hand, you should be able to spot it with your naked eye in the slightly darkened sky.

Then, almost as soon as it began, the Moon's leading limb breaks the ring of sunlight and annularity ends. For the next 90 minutes or so, the Moon slowly relinquishes its grip on the Sun as its shadow speeds off to the east.

Get Ready for the Big Day

The annular eclipse will last between three and three-and-a-half hours from start to finish. This might seem like plenty of time to see and do everything you want to, but you'll quickly find that's not the case. Time has a strange way of becoming compressed during an eclipse. And to compound the problem, most of the action and excitement occur during the few moments right around maximum eclipse.

If you intend to view the eclipse with a telescope or photograph the eclipse, plan on arriving at your observing site at least an hour or two before first contact. This will give you plenty of time to set up your equipment and to be sure it's operating properly. After all, you don't want to find out that your camera's not working or that you left your eyepieces in the hotel room just as the Moon slips completely inside the Sun's disk.

The six minutes of annularity will be the last time observers in the United States will see an annular eclipse for 18 years. Not until May 20, 2012, will the Moon again appear to pass within the Sun, as seen from the western part of the country. And it will be seven years after that before the Moon completely blocks the Sun from view. So don't miss your opportunity this May 10 to see the rare ring of fire. ☐

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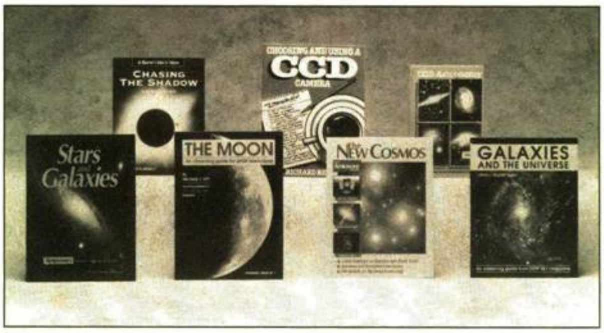

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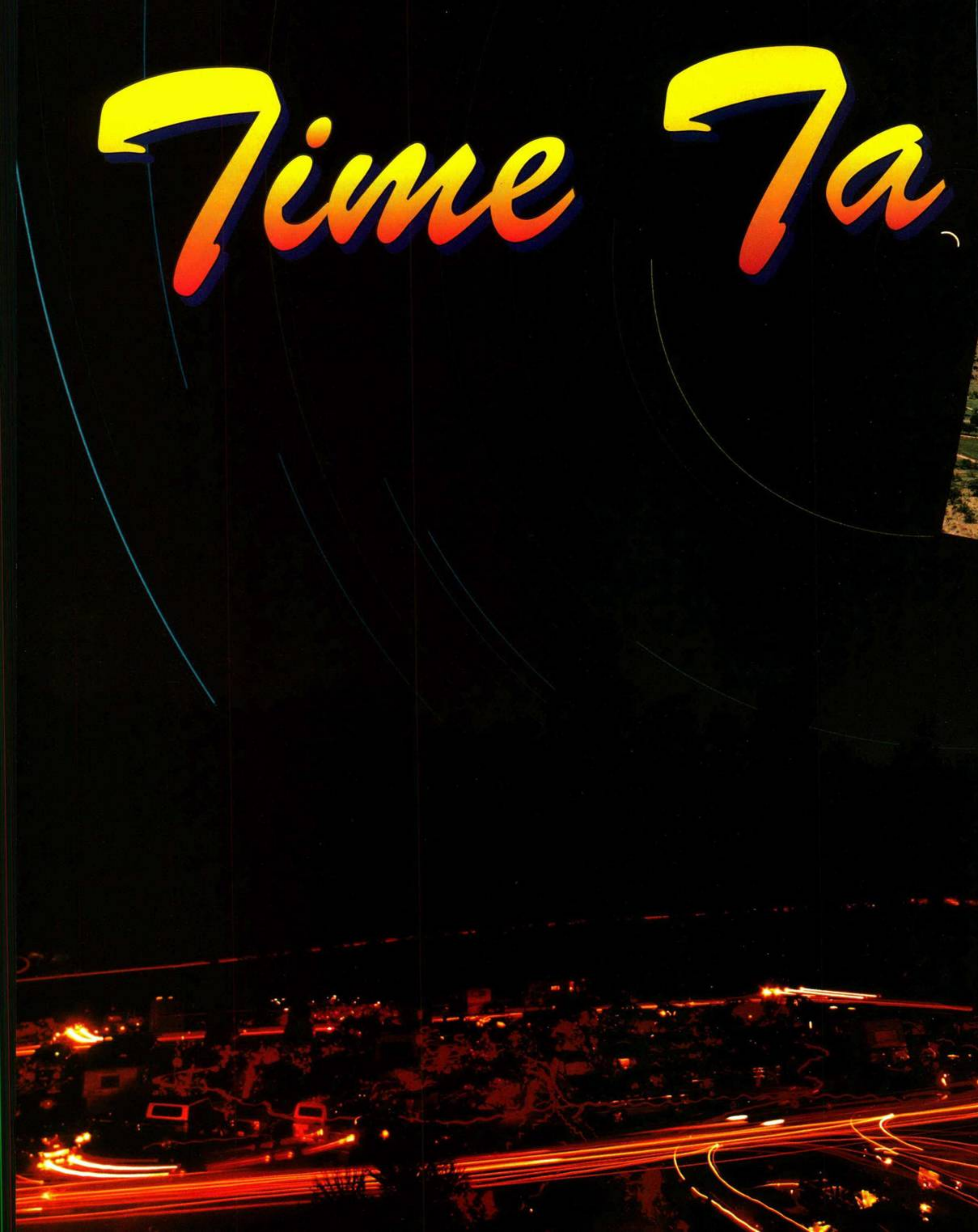
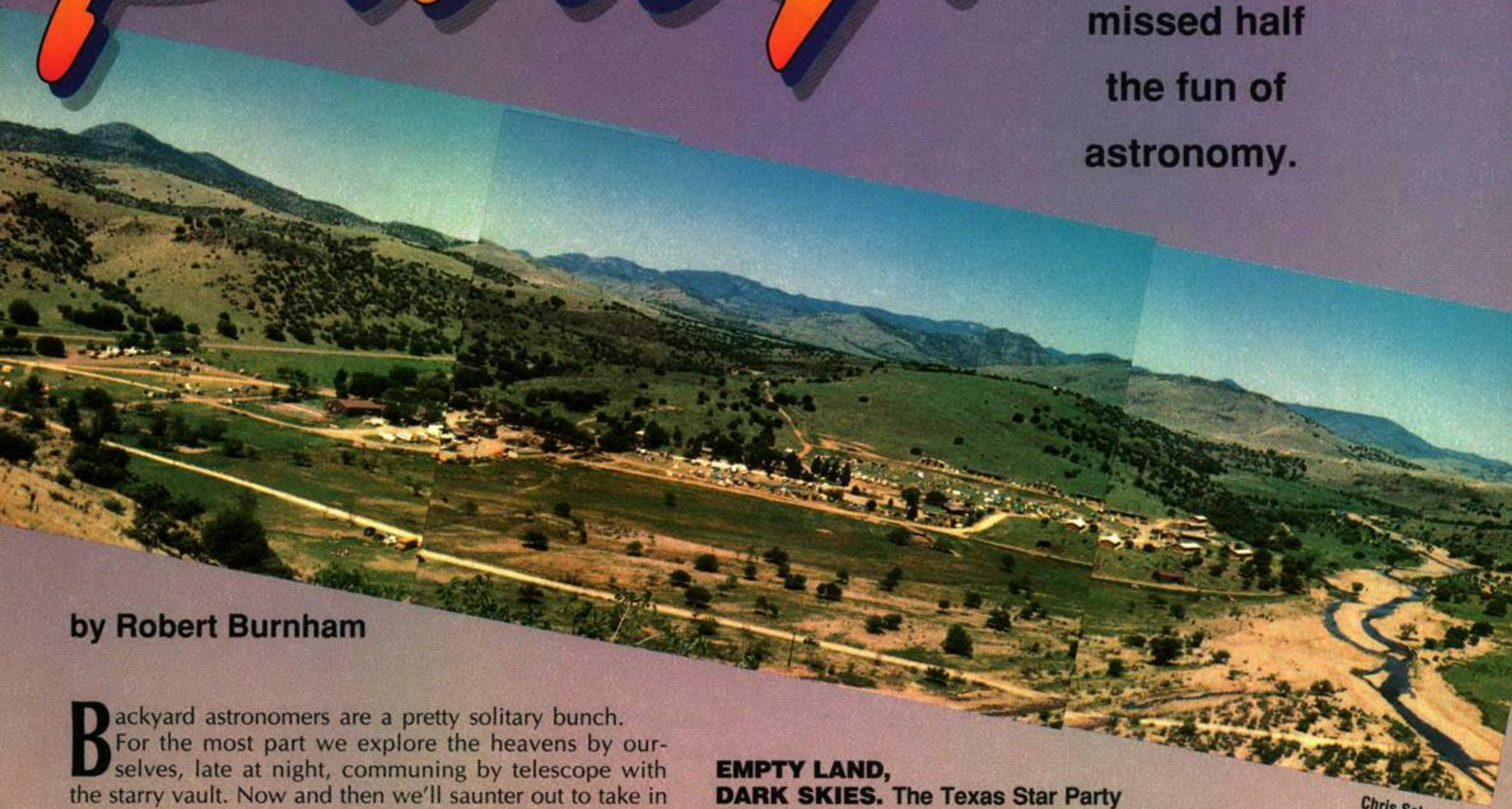


Party!

If you've never been to a star party, you've missed half the fun of astronomy.



EMPTY LAND, DARK SKIES. The Texas Star Party in Ft. Davis has an excellent site at the Prude Ranch only 12 miles from McDonald Observatory.

Chris Schur

by Robert Burnham

Backyard astronomers are a pretty solitary bunch. For the most part we explore the heavens by ourselves, late at night, communing by telescope with the starry vault. Now and then we'll saunter out to take in a meeting of the local astronomy club. Typically, though, the average backyard astronomer is so much a lone soul that it's easy to conclude that sky gazing has no social aspects to speak of.

But this impression couldn't be more wrong. Every year, all across North America, amateur astronomers and telescope builders hit the road to get together in a number of gatherings that last from just a weekend to upwards of ten days in a row. Some meetings focus on observing; others, it's showing off the telescope you've built. These are places where you can set up your scope amidst a field of them, meet other amateurs, and swap lies, trade equipment, look through dozens of different telescopes, stay up all night, and have a grand ol' time out under the stars. If you've never attended one — let me tell you, you don't know just how much fun astronomy can be.

New star parties begin every year and older ones are growing in size. While many meetings are relatively small and serve mainly a local area, others are giants that draw upwards of 2,000 people from all over — even from overseas. The events profiled here are just the tip of the iceberg. The star party calendar runs heaviest from late spring through early autumn, but there's even one in February, during the dead of northern winter. (Of course, it *is* in the Florida Keys.) So why not cut loose this year? Spend the whole summer traveling from one party to the next?

Okay, ugly reality now intrudes. Life, in the form of jobs, family, careers, school — all that boring stuff — won't ever let you do it. But if you could pay a visit to each of the major star parties this year, what would it be like? Let's find out.

May's a perfect time to begin, with two star parties in the program. First up is the Texas Star Party, which runs this year from May 8 through 14.

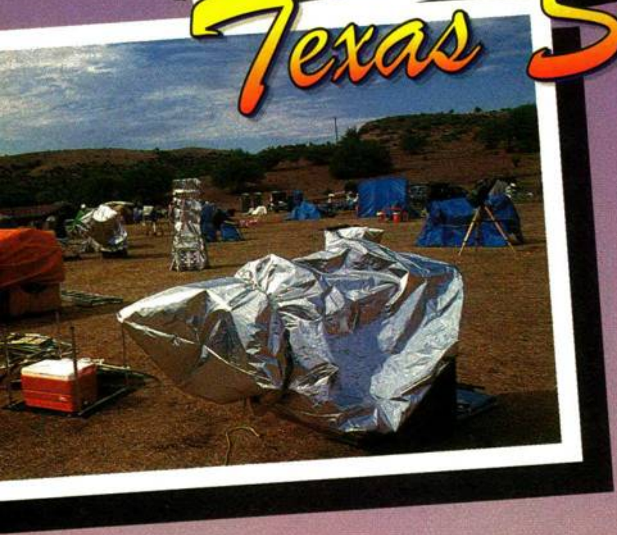
Home base for the TSP is the Prude Ranch in Ft. Davis, Texas, a little town in the Davis Mountains about 3 hours east of El Paso. Whether you arrive from the east, west, or north, tiny Ft. Davis lies well off any beaten path. Which is exactly why the University of Texas sited McDonald Observatory near it — and why the TSP offers the darkest skies of any of the large star parties.

Dark skies are the key because the TSP is mainly an observer's meeting. Telescope builders bring their scopes, of course, and you can compete for awards in design, optics,

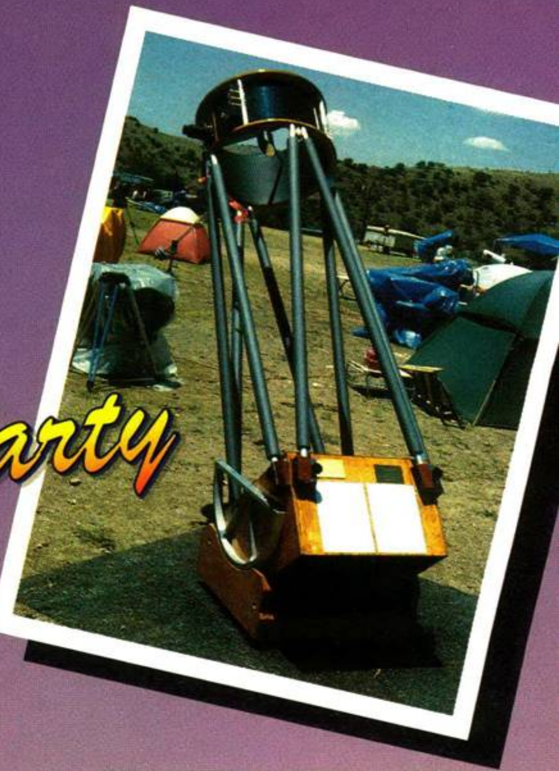
BACKYARD ASTRONOMY GETS SOCIAL as this weekend get-together at California's Mt. Pinos demonstrates.

Tony and Daphne Hallas

Texas Star Party



ASTRONOMY: both by Robert Burnham



John Love

YOU'LL SEE BIG SCOPES at the TSP, thanks to the dark skies that draw observers from all over the country.

Texas Star Party
Prude Ranch
Ft. Davis, Texas
May 8-14, 1994
Contact: TSP Registrar
1326 Mistywood Lane
Allen, TX 75002

and so on. But most of the 900 attendees come to see TSP skies. How dark are they? Well, the zodiacal light is bright enough to make hunting for deep-sky objects within it a little tricky. And when the Milky Way rises over the hills to the east, first-timers usually mistake it for cloud banks rolling in. Dark enough?

There's astronomy action of a different kind during the day. That's when you can stroll around the vendors' area inspecting telescopes, eyepieces, finderscopes, books, software, and all sorts of accessories brought by a dozen or more dealers. And who'd want to miss the swap meet? Telescopes, accessories, cameras, books, magazines — you name it, it's all for sale or trade, at the marked price or whatever you can haggle the owner into taking for it.

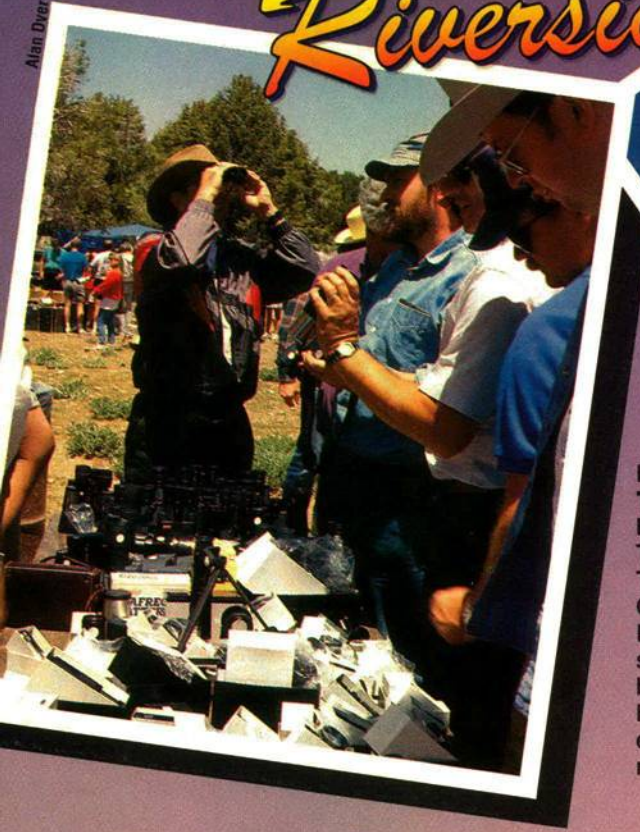
If your wallet's empty, check out the speaker's program. All afternoon and into the early evening fellow amateur astronomers give slide shows and talks about their experiences. You might see beautiful color astrophotos, or hear how somebody built an observatory, or discover how a club brought astronomy to an inner city school. Or maybe you'll experience computerized image processing firsthand, trying it yourself on a galaxy picture someone took the night before.

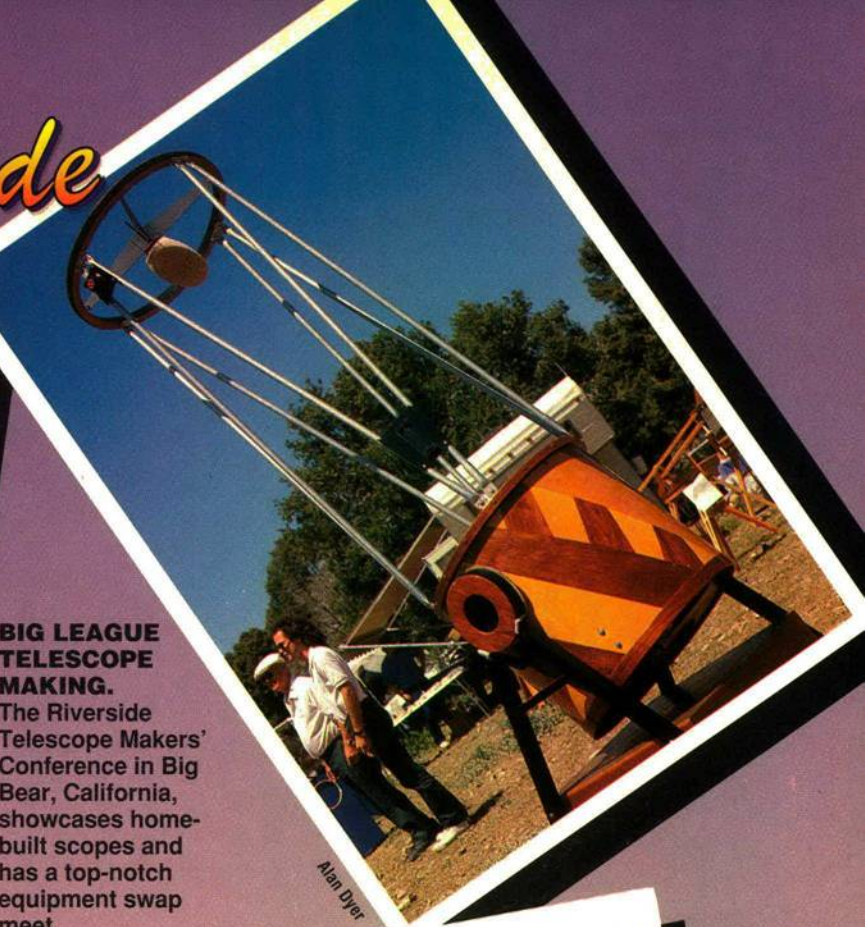
The TSP has three large areas for telescopes. Unless you've seen its like before, the sight of a couple hundred scopes all in one place is overwhelming. During the day, they're usually shrouded with tarps to protect them from Sun, dust, and the occasional rain shower. But as dusk falls, the air grows cool and people begin to unwrap them. You return to your tent to get a sweater and your red-lensed flashlight. A few nighthawks and bats swoop against the deep twilit sky as you head out to the ballfield to wander among the telescopes.

Against a background of soft laughter and talk, you make out groups of viewers clustering around instruments of all sizes: stately refractors, giant Dobsonian reflectors, and lots of ordinary telescopes perhaps just like yours. Here everyone's looking at the Whirlpool Galaxy; over there it's the Veil Nebula. The truth is you don't need to bring a scope. Just walk around and join a group.

The night rolls on toward the wee hours and voices dwindle as the easily satisfied call it a night. You have your red flashlight, but by now you are so dark-adapted that you can walk around by starlight. In the early a.m. hours, the Milky Way stands up tall and utterly beautiful. You explore its bright starfields and dark nebulae with telescopes, binoculars, even the naked eye. You've never seen anything like it before — it's a sight to burn into your mind forever.

Riverside


Alan Dyer


Alan Dyer

BIG LEAGUE TELESCOPE MAKING.
The Riverside Telescope Makers' Conference in Big Bear, California, showcases home-built scopes and has a top-notch equipment swap meet.

By the time chilly dew has wet most surfaces, your eyes feel grainy with fatigue. It seems almost sinful to go to bed with so much starlight still on display. But weariness wins. And after all, there's tomorrow night and the one after still to go.

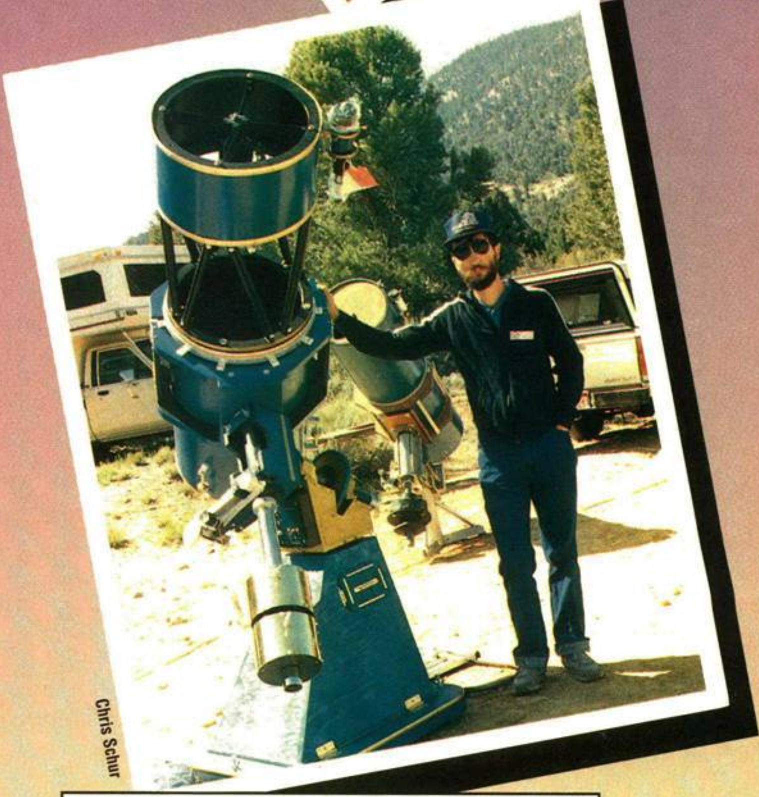
For accommodations, the Prude Ranch offers a few motel rooms and several cabins where people share a bathroom. Most visitors however camp out, either in tents, trailers, or RVs. This year organizers timed TSP to include the annular solar eclipse on May 10. While the path of annularity will miss the ranch, TSP organizers are arranging for an expedition to Sierra Blanca, a small town on the interstate toward El Paso lying inside the eclipse path.

Following on the heels of the TSP is the Riverside Telescope Makers' Conference, held over Memorial Day weekend. Attracting some 1,500 people, Riverside (or RTMC as it's also known) is the real birthplace of the Dobsonian reflector. John Dobson may have invented this type of telescope up in the San Francisco Bay area, but it was Southern California's telescope makers who perfected it.

The meeting's name, however, is a little misleading. While once held in the city of Riverside, California, the conference now meets at Camp Oakes, high in the mountains northeast of Los Angeles, on the outskirts of the resort towns of Big Bear City and Big Bear Lake.

The contrast between Camp Oakes and the smoggy L.A. basin couldn't be more stark. For one thing, more than a mile of altitude separates them. It may be broiling down in L.A., but the pine scrub around the telescope meeting always seems refreshing. The camp offers bunkhouses (bring your own bedding) and space for tents and RVs. There's a big dining hall for meals — or if you prefer, a 10-minute drive takes you back to Big Bear's restaurants.

Riverside's focus differs from the TSP's. It does offer observing but the main draws are telescopes and knowledge-


Chris Schur

Riverside Telescope Makers' Conference
Camp Oakes
Big Bear, California
May 26-30, 1994
Contact: RTMC
Fox & Stephens, CPAs
9045 Haven Ave., Suite 109
Rancho Cucamonga, CA 91730

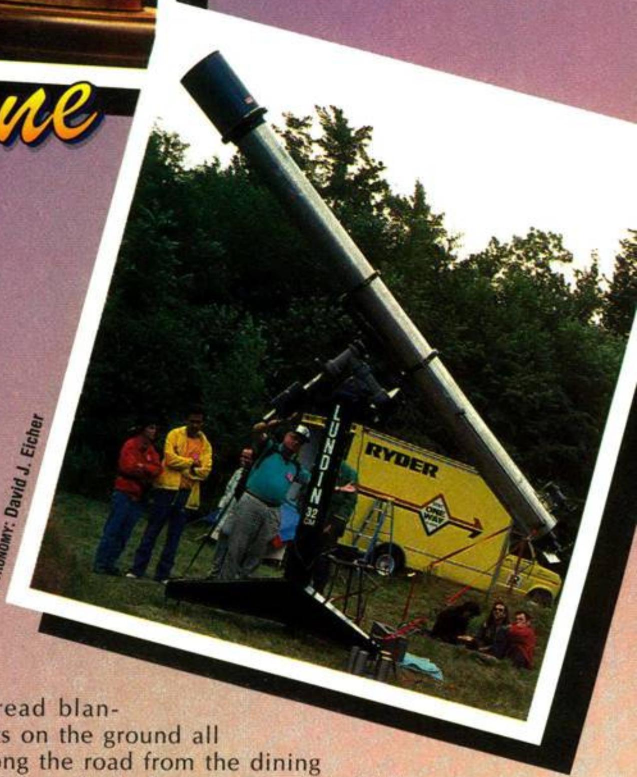
Kevin Jones

STAR TRAILS OVER THE CLUBHOUSE. An East Coast mecca for amateur astronomers, Vermont's Stellafane has brought telescope makers together for decades.

David Healy

Stellafane
Springfield, Vermont
August 5-7, 1994
Contact: Stellafane
P.O. Box 50
Belmont, MA 02178

Stellafane



ASTRONOMY: David J. Eicher

able talks about them. For amateur telescope makers, Riverside is definitely Big League. Here's where highly skilled builders bring their beautiful creations for the admiration and scrutiny of their peers. Some telescopes feature sophisticated optical designs; others display fine craftsmanship that would be the envy of any cabinetmaker or machinist.

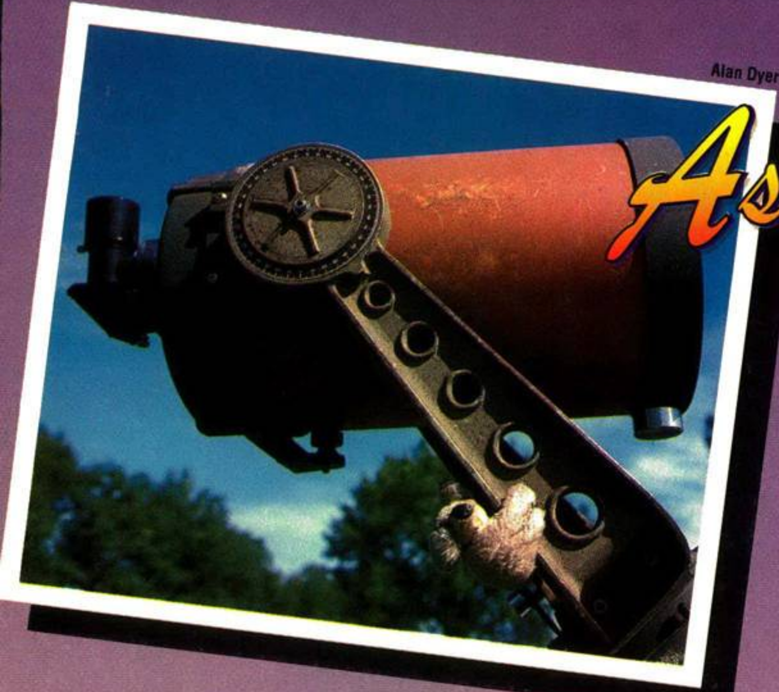
A team of tough judges checks over the entries in several categories and makes merit awards on the last night of the meeting. The proud owner of an award-winning scope gets a small brass plaque to note the award and attaches it to the telescope. As you walk around, you'll spot winners from previous years by these "hash marks," and you can test them at night against this year's contenders.

Commercial telescopes are popular at Riverside too. Manufacturers and dealers, many based in the area, make the trip up to Riverside to show off new products — and also to see what the home-builders are doing. Many products you see in the ads and catalogs began in the workshops of amateur telescope makers. Another popular feature are the sales of factory "seconds" — telescopes, mountings, and accessories with slight defects — at heavy discounts.

Riverside's swap meet — every star party has one — may be the best of all. People set up card tables and spread blankets on the ground all along the road from the dining hall to the field where most commercial displays are. Many visitors feel that you can find more high-tech surplus optical gear at Riverside than anywhere else. It's a giant open-air astronomy bazaar and the haggling gets as fierce as any in the Middle East.

The talks presented in the dining hall during the afternoon and early evening are equally high-power. You'll hear lots of discussion about optical testing and strong opinions on telescope designs and commercial scopes.

Riverside is famous for its weather. During the daytime, it's usually sunny and hot enough for T-shirts and shorts (watch out for sunburn!). But on a few memorable occasions, the meeting has been held amidst a heavy snowfall. Rain squalls can blow through at any time, sending everyone scurrying to cover up telescopes, and mountain winds can kick up dust. Old-timers will tell you to bring plenty of warm clothing: 90° in the afternoon will sink to 45° by late evening as the thin desert air gives up its warmth quickly.

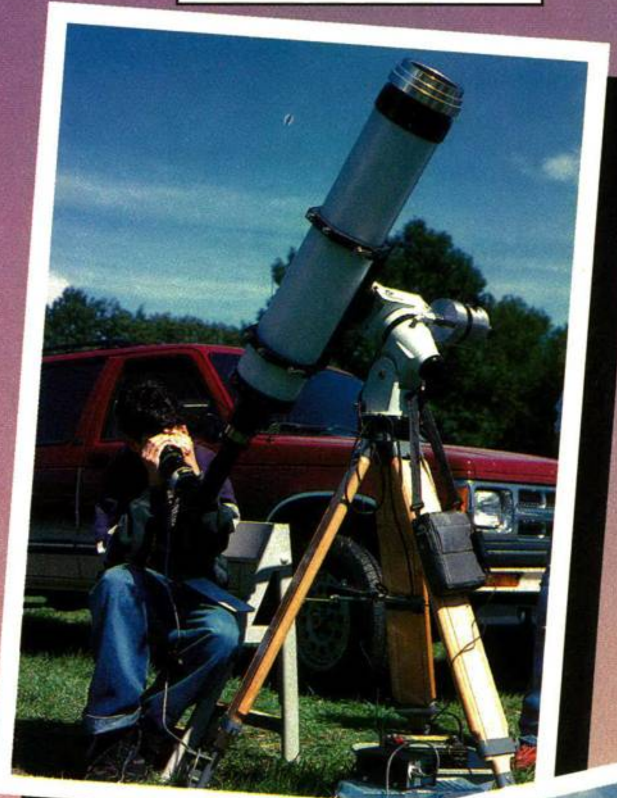


Alan Dyer

Astrofest

Astrofest
Camp Shaw-Wah-Nah-See
Kankakee, Illinois
September 9-11, 1994
Contact: Astrofest
P.O. Box 596
Tinley Park, IL 60477

IN THE HEART OF THE MIDWEST, Astrofest blends observing and telescope displays — both big and little, old and new.



Alan Dyer

ASTRONOMY: Robert Burnham

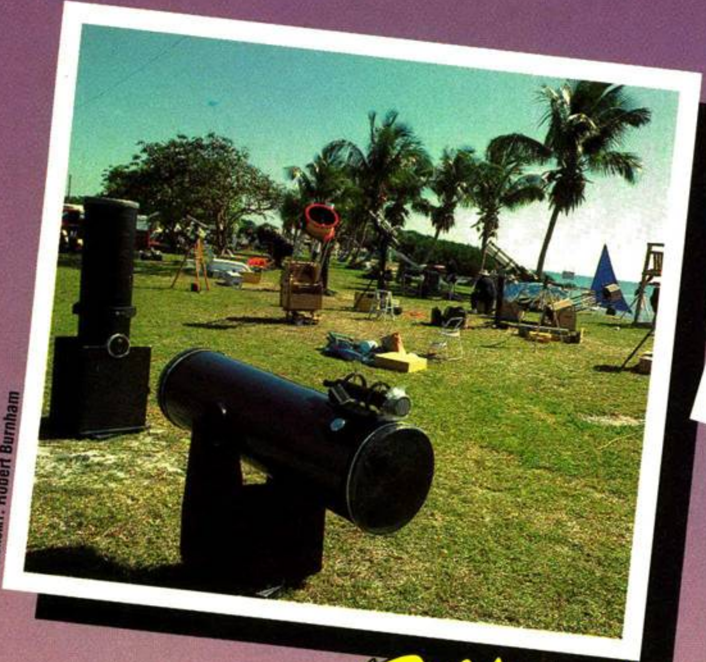
If Riverside has an ancestral spirit, its name is Stellafane. This is the granddaddy telescope-makers' meet of them all. Stellafane is tradition and optics and fine workmanship all set amidst the lushness of late summer Vermont. Amateur telescope making may not have begun here, but this weekend gathering in early August, which draws about 1,500 people each year, made it famous the world over.

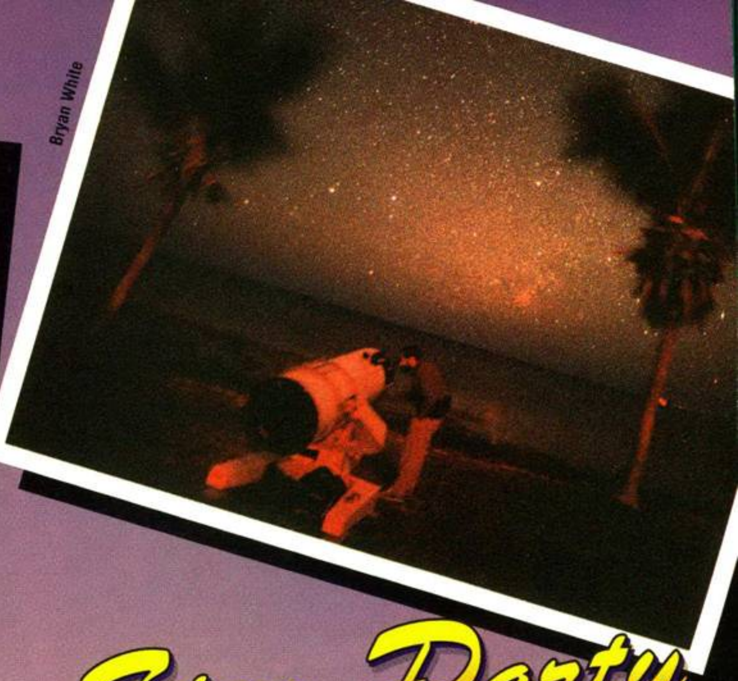
The Springfield Telescope Makers of Springfield, Vermont, is a club with a pedigree second to none. Russell W. Porter — one of the designers of the Palomar 200" — was the driving force in the club, and no one did more than he to popularize amateur telescope making since the 1920s. He died in 1949, but his ghost still hovers over the meeting, which is named for the pink wooden clubhouse, the "Shrine to the Stars," which Porter designed and built.

Stellafane is a short meeting, lasting from Friday afternoon through Sunday morning (August 5 to 7 this year). Into those 48 hours, visitors cram a world of telescope activity. You'll see new telescopes, new designs, new accessories — all built by amateurs. Telescopes that collapse to form a small cube that rides on the back of a motorcycle. Huge refractors that rival some Dobsonians in aperture. Clever observing chairs that adjust to suit any height. Special-optics reflectors that offer refractor-like performance using mirrors only.

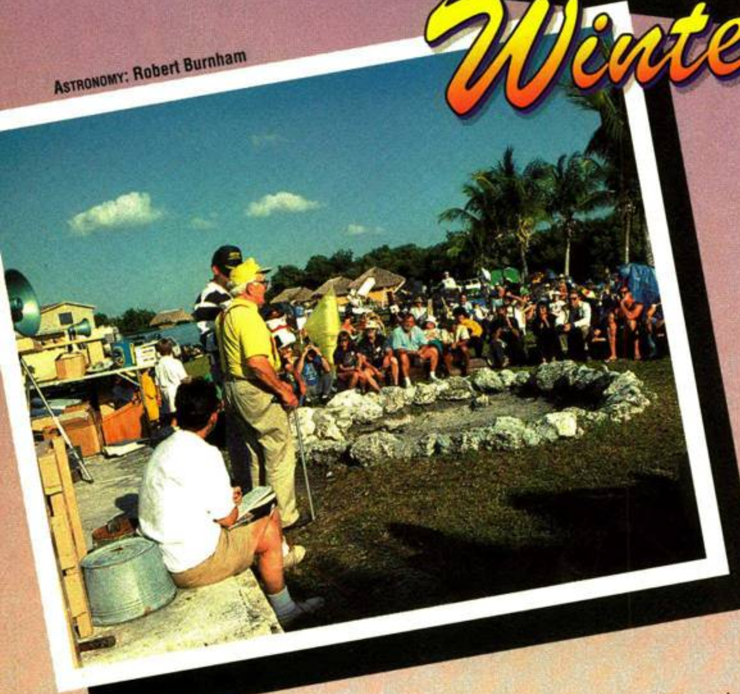
You'll see lots of old telescopes and equipment, too: beautifully restored Clark refractors with brass tubes and weight-powered clock drives. Varnished wood cases holding ranks of brass eyepieces and filar micrometers. Tripods that were new a century or more ago. You often hear that old telescopes can outperform today's models. At Stellafane you can put this claim to the test, as in most years you'll see at least a few antique telescopes among the many newer ones.

What you *won't* see are commercial displays. Stellafane differs from most other meetings in that it bans displays by dealers and manufacturers. The only equipment for sale is at the swap meet, perhaps the best apart from Riverside's. Only private individuals are allowed to sell or trade their


ASTRONOMY: Robert Burnham


Bryan White

Winter Star Party


ASTRONOMY: Robert Burnham

excess equipment and just like out west, the swapping can reach fever pitch.

During the day you'll hear talks from amateur astronomers on every telescope-making topic imaginable. Come nightfall, if the sky is clear, the familiar round of observing takes over.

As you wander from the clubhouse area through the woods to the hillside where everyone camps, it's like strolling along a New England farm lane. The rugged wooded hills, with boulders of bedrock sticking up everywhere, make this unmistakably Vermont. It's not quite Robert Frost country, but you sense his Vermont lies just over the ridge. There's a feeling of seriousness and purpose about Stellafane, but it's less intense than that which permeates Riverside. And, just as with Riverside, winning an award for telescope making at Stellafane puts you squarely in the Big League.

East coast, west coast — what about in between? Down near Kankakee, Illinois, southeast of Chicago, you'll find Astrofest. Held this September 9 through 11, Astrofest gives an opportunity for midwestern astronomers to get together, show off scopes, and observe under dark skies. Astrofest lies within easy driving range of a large population. As a result, it has become the Middle West's biggest meeting, with about 700 attendees most years.

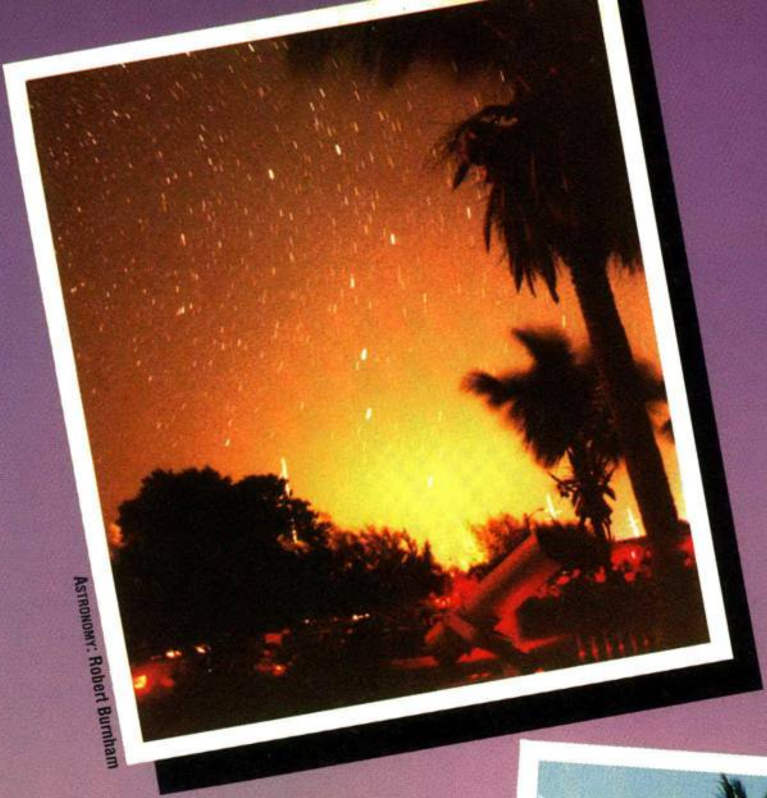
If there's such a thing as a "general" star party, Astrofest could well be it. It's an observer's meeting — skies are dark enough to make big telescopes worth bringing — and it's also a telescope maker's meeting because you'll get lots of knowledgeable ideas and comments when you bring a homebuilt telescope. Astrofest has a lot for the astrophotographer, too, and it offers much for those who are shopping for new or used equipment. It's about as classic a mix of people and telescopes as you could wish for.

Astrofest is held on the grounds of a 4H camp that surrounds a scenic rocky ravine, rich in fossils. Most visitors camp out on the vast ballfield beside their telescopes, but a number of cabins offer bunk spaces as well. The city of Kankakee, about 10 minutes away, throws a glow into the night sky, but it lies due east from the star party and celestial objects climb out of its glow.

As autumn settles in, star party activity slows. Meetings tend to be local and often focus more on indoor activities such as talks and workshops. With the arrival of winter, most observers are thrown back on their own resources. Except for one meeting.

Just when you really need a break from the rigors of winter, there's the Winter Star Party, held in the lower Florida Keys, February 27 to March 5, 1995. For most northerners, the WSP wouldn't have to offer much to get their attendance. Blue skies, blue water, and warm air could pretty well do it alone! But the WSP offers two more wonderful things: fine dark nights and a latitude of 25° north. Combine these with the others and you have a perfect recipe for comfortable midwinter viewing.

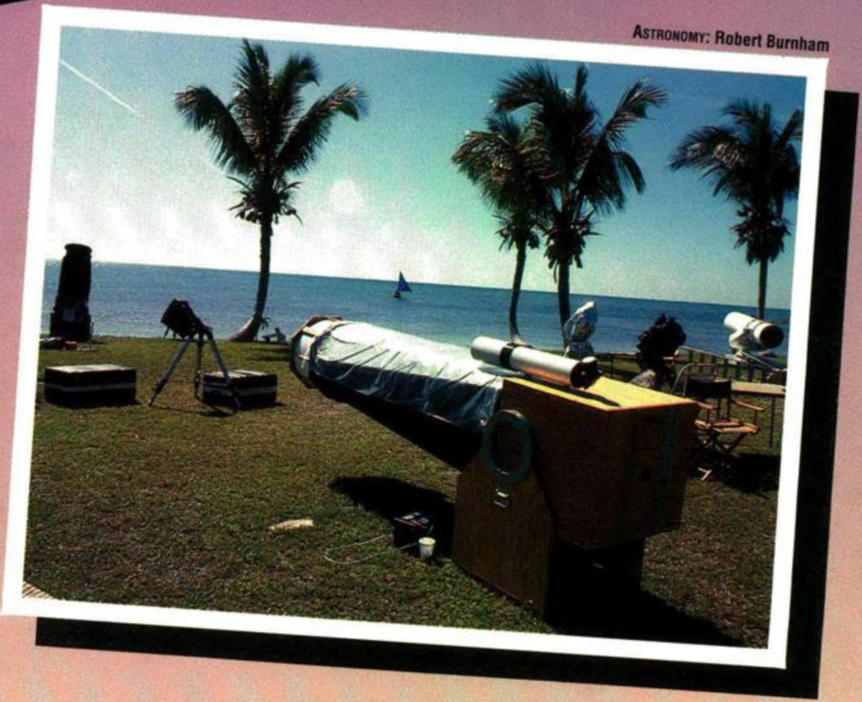
The Winter Star Party meets at a scout camp on West Summerland Key, between Big Pine and Marathon. This is most of the way out to Key West from Miami. West Summerland is one of the smaller keys, but the meeting



ASTRONOMY: Robert Burnham

WINTER OBSERVING IS *SO* HARD . . . especially when palm trees block your view of Carina and Centaurus. Winter-weary astronomers flock to the WSP, held in the Florida Keys every February, eager for dark skies and far southern celestial objects.

Winter Star Party
Camp Wesumkee
West Summerland Key, Florida
February 27-March 5, 1995
Contact: Bob Grant
5401 SW 110th Ave.
Miami, FL 33165



ASTRONOMY: Robert Burnham

still handles about 800 people. Accommodations are the usual: cabins with bunks and camping and RV spaces. You can get a meal ticket to eat on-site or scoot into Big Pine or Marathon.

Unless you're from Florida, what will strike you most strongly about the WSP are its contrasts: winter constellations and warm nights. Orion glittering through wind-tossed palm branches — and much higher in the sky, too. The Big Dipper vanishing below the pole, and the Southern Cross well up in the south. You'll get your first views of Alpha Centauri and of Omega Centauri and Eta Carinae also. You'll find a Milky Way that doesn't stop at Sagittarius but goes on and on and on.

Sights like these lend a delightful unreality to the star party. At night you'll wander around talking astronomy and telescopes while the constant sound of surf beats in the background. By day, steady trade winds bend the palms under puffy clouds into a scene familar from dozens of corny South Seas movies. But instead of hula-dancers, you'll see hundreds of telescopes.

The week will pass all too fast, in long nights and busy days. Soon you'll be back home, with Orion in its usual place, framed in bare tree branches over snow-clad fields. But for now, it's extremely pleasant to lean against a palm trunk, sniff the ocean breeze, and prowl the Milky Way with your big binoculars, down to where it vanishes into the distant waves.

With all this partying, you should be exhausted. After all, there is a limit to the number of back-to-back all-nighters anyone can pull.

Those mentioned here are by no means all the star parties and meetings across the land. They're simply a selection of the largest. To stay in touch with all that's going on — and to make your summer star party plans complete — check out the "Meetings and Events" column in ASTRONOMY each month.

The star party year has finally wound down. You unpack the now well-traveled telescope, eyepieces, and box of gear. You get to thinking over all the neat telescopes you've seen, and you start to wonder about the next one you might buy — or build.

Most of all, though, you remember all the new friends you've met. Is astronomy a solitary pursuit? No way. It's full of enough people, places, and things to fill a lifetime. □

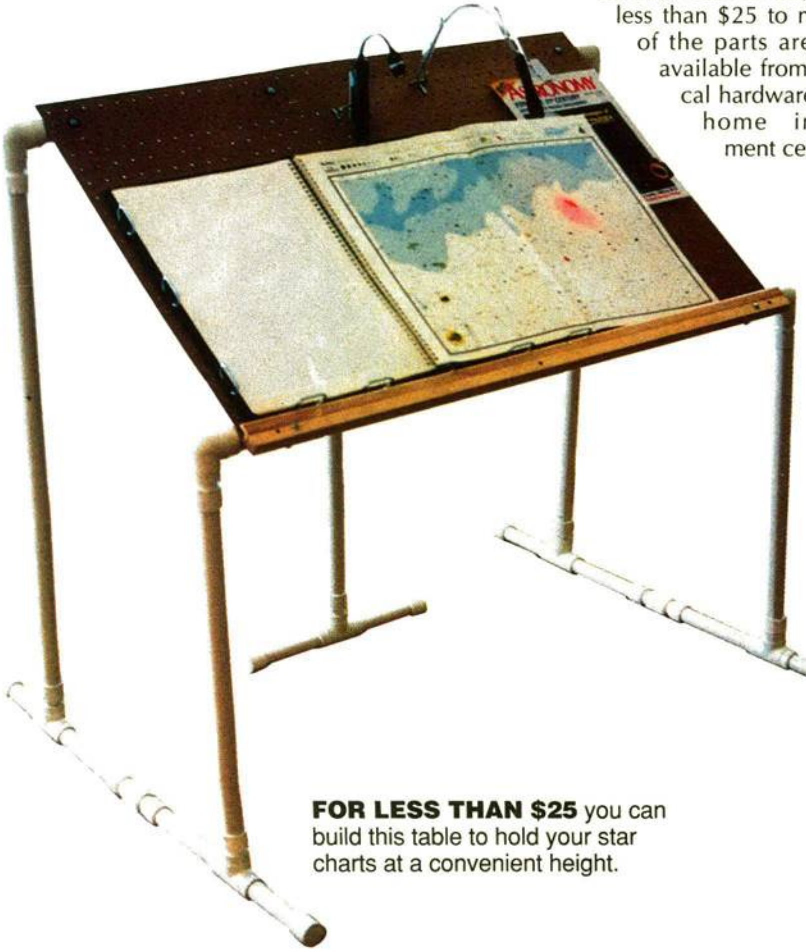
BUILD A TABLE FOR YOUR STAR CHARTS

This table will keep your atlases and papers out of the dew and protect them from a misguided footstep in the dark.

Story and photos by Deannea Dagilis

Trying to move my telescope while holding a copy of *Sky Atlas 2000.0* with one hand and a flashlight in the other is a trick I never mastered. Inevitably I had to put the chart on the telescope case while pointing the scope. When I went to recheck a position on the chart, I had to crouch uncomfortably over the case and atlas. Sometimes the chart ended up on the ground, mixing with the dew and getting stepped on accidentally. And when the wind kicked up, it flopped the pages around, so I'd lose my place in the atlas.

But no more — I solved my problem by building a chart table. It is lightweight, holds my charts securely, disassembles easily for transport to my observing site, and has a flashlight mounted on it for viewing the chart (a red one to preserve night vision). Best of all, it costs less than $25 to make. All of the parts are readily available from your local hardware store or home improvement center.



FOR LESS THAN $25 you can build this table to hold your star charts at a convenient height.

With a 24" by 36" top, the table is more than big enough to hold *Sky Atlas 2000.0* (16" by 31½" when fully opened). Two cross supports fasten the top to the five legs. The fifth leg, located at the table's back, adds stability to the table.

Start at the Top

The first piece to assemble is the table top. It's a standard 24" by 36" sheet of ⅛"-thick pegboard. Pegboard (sometimes called perforated board or perfboard) is lighter than solid hardboard and its holes help keep the wind from blowing the table over. The holes also let me use pegboard hooks (such as the ones designed for pliers) to hold down the star atlas pages when it's windy. You may want to seal the pegboard with an exterior paint or varnish if you observe in dewy or humid conditions. Use an oil-based finish to prevent the fibers in the hardboard from peeling.

I added a lip to the bottom edge of the pegboard to hold papers. To do this, I used three ½"-long #6 wood screws to fasten a 3-foot long piece of ¾" pine corner trim (L-shaped) to a 3-foot long piece of ¾"-square pine. Two 1½"-long 8-32 bolts secure the lip to the pegboard. When observing I use pegboard hooks (pliers type as above) to prevent star atlases from getting caught under the lip (see photo at left).

Five Legs to Stand On

Now it's time to make the pieces that hold up the top. Fashion the table legs and supports from light ¾" PVC (Schedule 40) pipe and standard PVC connectors. If you use cemented connections for most of the pipe joints and threaded fittings where the legs join the feet and pegboard supports, the table assembles and stores easily.

You don't need to cement the connections since most pipe fittings provide a tight fit. But you may find some of the fittings are loose or that the joints loosen with use. So it's probably best to cement the joints — except, of course, at the threaded fittings. Your hardware dealer can help you select the PVC cement recommended for use with your pipe. However, don't cement any of the joints until you fashioned all the pieces and assembled the table to ensure that all the pieces are the proper length.

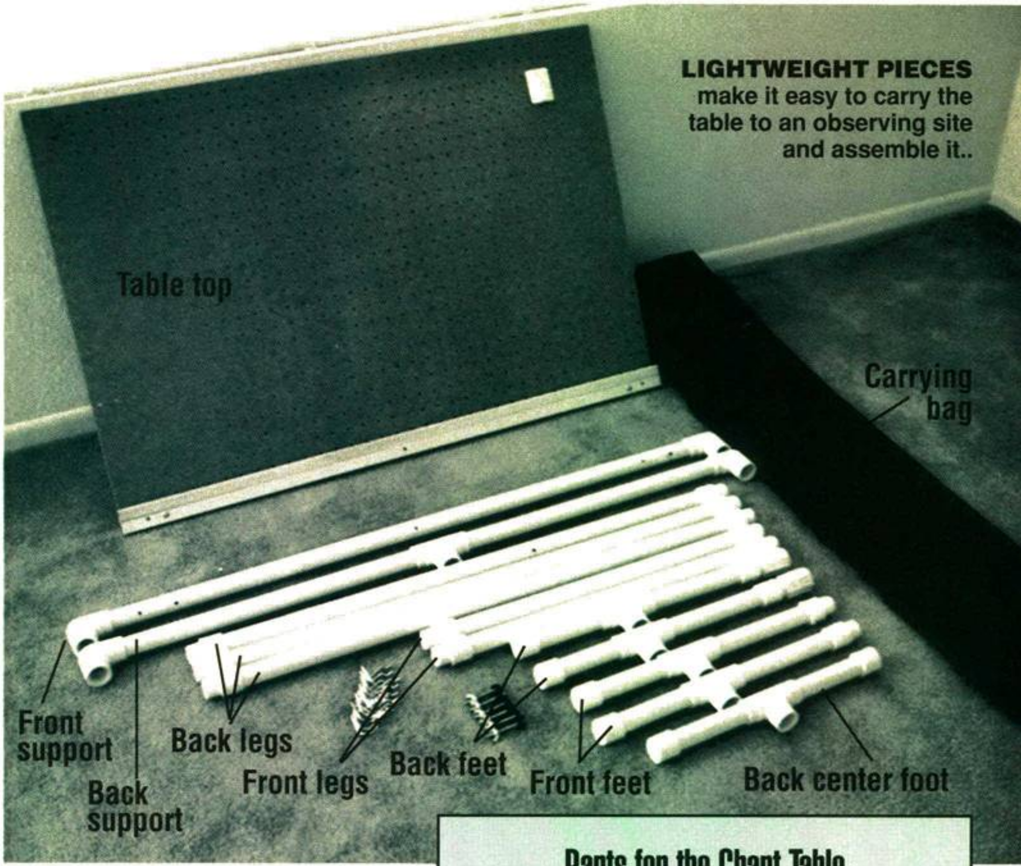
The dimensions given below allow me to slide my lawn chair (its arms are 20" high) under the table. For a taller chair you may wish to add height to the legs. Also the dimensions assume that 1/2" of pipe seats in each connector. Slip one end of a pipe into each type of connector you have and make a pencil mark on the pipe near the fitting. Remove the pipe and measure from its end to the pencil mark to determine the seat allowance. If it's not 1/2", modify the leg lengths to make sure your chair will slide under the table. Remember you have to allow for the pipe seating on both ends.

Start the leg assembly by making the pegboard supports. Cut the front one 37 1/4" long and slip a 90° elbow fitting on each end. A hacksaw or fine-toothed saw will cut the pipe easily, although you may need to smooth the ends with a file or sandpaper. The back support uses two 17 1/2" long pieces of pipe. Join the pieces with a tee fitting (so-called because it looks like a "T") and slip elbows on the ends. Check that the front and back supports are the same length.

The three back legs are identical. They are 30 1/8" long and have threaded adapters on both ends of each leg. The two front legs are 18 1/2" long and also have threaded adapters on each end. The threaded adapters screw into the pegboard supports and into the feet that we'll make next.

A solid foot for the legs on each side won't work in this design. After you screw the legs into the pegboard supports, you can screw only one of the two legs onto the solid foot. So make two feet for each side and then use a threaded pipe coupling, or union, to join the feet after you screw each leg into place. You could omit the union but coupling the feet together adds to the rigidity of the table.

The two back feet each have a 4 3/4"-long pipe and a 6 1/2"-long pipe joined with a tee fitting. A cap goes on the shorter pipe and a threaded adapter on the longer one. The two front feet each have 5"- and 6 3/4"-long pipes joined with a tee, a cap on the short pipe, and a threaded adapter on the longer one. The third leg in back has two 4"-long pipes joined with a tee and capped on both ends.



LIGHTWEIGHT PIECES make it easy to carry the table to an observing site and assemble it..

Parts for the Chart Table

Quantity	Item
1	1/8"-thick pegboard, 24" x 36"
1	3/4"-square pine, 36" long
1	3/4" pine corner trim, 36" long
3	#6 wood screws, 1/2" long
2	8-32 bolts, 1 1/2" long
4	#8 washers
2	#8 nuts
4 to 8	pegboard hooks for pliers
3	3/4" PVC pipe (Schedule 40), 10' long
6	3/4" PVC tee, middle outlet threaded
6	3/4" caps
14	3/4" threaded adapters
2	3/4" threaded union
4	3/4" 90° elbows, one end threaded
6	8-32 bolts, 2" long
12	#8 nylon or rubber washers
6	#8 wing nuts
	PVC cement optional

Putting It All Together

With the legs, feet, supports, and top completed, you can now assemble the table. First screw the legs into the pegboard supports, front legs into one and back legs into the other. Then screw the feet onto the legs. You can recognize the front feet because they are slightly longer than the back ones. Stand the leg assemblies up and screw together the front and back feet on each side using a union.

Using clamps, tape, or the help of a friend, attach the pegboard to the supports. Position the pegboard so a line of holes lies over each support. If you can't line up holes on both supports, align them on the back support. In that case, you'll have to drill through the pegboard for the front support bolt holes. Drill four 5/32" holes in the back support to take the 2-inch-long 8-32 bolts. Locate two holes near the back side legs. The other two are evenly spaced in between. Drill two holes in the front support near the legs.

With the holes drilled, attach the pegboard to the supports using washers, bolts, and wing nuts. Rubber or nylon washers allow some compression and help prevent the pipe from splitting, but don't over-tighten the wing nuts.

To assemble the table in the field, follow the same steps. Screw the legs into the supports and the feet into the legs. With the supports standing on their own two feet (or three), bolt the pegboard to the supports. Finish by screwing the feet together using the unions.

To make carrying the table to my observing site even easier, I made a carrying bag from a 22" by 48" piece of sturdy cloth. A 30"-long nylon cord forms a drawstring for closing the bag. Spring binder clips make a useful accessory for holding papers onto the pegboard.

Sure a chart table is a luxury for backyard observers. But once you build and use one, you'll wonder why you didn't make it years ago. ☐

Deannea Dagilis lives west of Phoenix, Arizona, and uses her chart table when she explores the skies.

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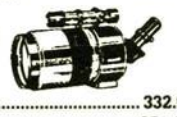

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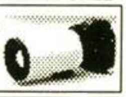

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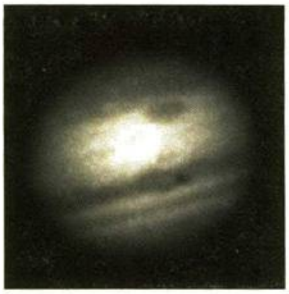

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(Note: The image that appeared in the April Astronomy advertisement was, through a production error, degraded in quality.)

MEETINGS & EVENTS

April 16
Astronomy Day, Brown University, Providence, Rhode Island. Sponsored by the Celestial Observers of Rhode Island. Contact Ken Conca, (401) 351-5676.

April 21
Monthly Observatory Night, Cambridge, Massachusetts. Contact Harvard-Smithsonian Center for Astrophysics, Public Affairs Office, 60 Garden Street, Cambrige, MA 02138, (617) 495-7461.

May 5-11
1994 South Pacific Star Party, Sydney, Australia. Sponsored by the Astronomical Society of N.S.W. Inc. Contact Treasurer, Astronomical Society of N.S.W. Inc., P.O. Box 1093, Darlinghurst, N.S.W. 2010 Australia.

May 6-8
1994 Southern Star Astronomical Convention, Monroe, North Carolina. Sponsored by the Charlotte Amateur Astronomers Club. Contact George and Mary Chakhtoura, 5023 Walt Gay Road, Monroe, NC 28110.

May 7-8
1994 Northeast Region of the Astronomical League, Schenectady, New York. Sponsored by the Albany Area Amateur Astronomers. Contact Sue and Alan French, R. D. 4, Box 205A, Scotia, NY 12302, (518) 374-8460.

May 9-15
Texas Star Party, Prude Ranch, near Fort Davis, Texas. Hosted by the Southwest Region of the Astronomical League. Contact TSP Registrar, 1326 Mistywood Lane, Allen, TX 75002.

May 19
Monthly Observatory Night, Cambridge, Massachusetts. Contact Harvard-Smithsonian Center for Astrophysics, Public Affairs Office, 60 Garden Street, Cambridge, MA 02138, (617) 495- 7461.

May 21
Astroganza 94, Abrams Planetarium, East Lansing, Michigan. Contact Kurt Melvin, Abrams Planetarium, Michigan State University, East Lansing, MI 48824, (517) 548-2423.

May 30
Riverside Telescope Makers Conference, Camp Oaks, near Big Bear Lake, California. Contact RTMC, Fox & Stephens, CPAs, 9045 Haven Avenue, Suite 109, Rancho Cucamonga, CA 91730, (909) 948-2205 (leave message).

June 4-6
4th Encuentro Nacional de Astronomía, Cali, Valle del Cauca, Colombia, South America. Sponsored by the Asoc. de Astrónomos Aficionados, the Grupo Antares de Aficionados a la Astronomía, and the Centro de Estudios Astronomicos. Contact Giovanni Barandica, 923-822624, Luz Marina Duque, 923-581175, or write to ASAFI, 4th Encuentro Nacional de Astronomía, AA 3189, Cali, Colombia, South America.

June 9-12
Astroblast '94, Oil Region Observatory, near Oil City, Pennsylvania. Sponsored by the Oil Region Astronomical Society. Contact Tom Bemus, c/o The Camera Infirmary, 120 East 3rd Street, Jamestown, NY 14701, (716) 664-4506, or (716) 386-4566.

June 9-16
Astronomy Camp for Teens (Basic), University of Arizona, Tucson, Arizona. Sponsored by the University of Arizona Alumni Association. Contact Lisa Roubal, 1111 N. Cherry, Tucson, AZ 85721, (602) 621-5233, or (800) 232-8278 outside Arizona.

June 10-11
24th Apollo Rendezvous and Telescope Fair, Dayton, Ohio. Sponsored by the Miami Valley Astronomical Society. Contact Kerry Harman, 2600 DeWeese Parkway, Dayton, OH 45414, (513) 837-4343.

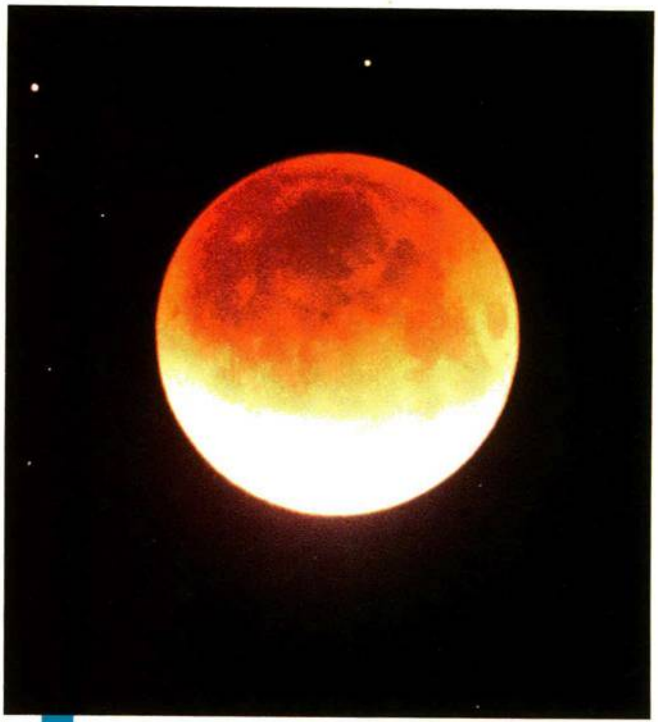
June 10-12
Annual Mason-Dixon Star Party, Spring Valley County Park, Pennsylvania. Sponsored by the York County Parks Astronomical Society. Contact Todd Ullery, R. D. #1, Box 5AA, Glen Rock, PA 17327, (717) 235-1153.

June 25-26
Universe 94, Northern Arizona University, Flagstaff, Arizona. Sponsored by the Astronomical Society of the Pacific and ASTRONOMY magazine. Contact the Astronomical Society of the Pacific, Meeting Information, 390 Ashton Avenue, San Francisco, CA 94112, (415) 337-1100. □

Clubs, please submit your announcements at least four months before the date of the meeting or event. Readers, please include a self-addressed, legal-sized envelope with your request for information.

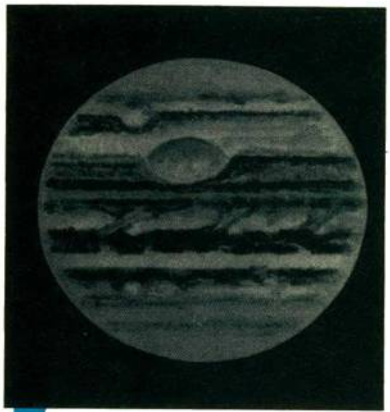
READER REPORTS

Viewing the Lunar Eclipse



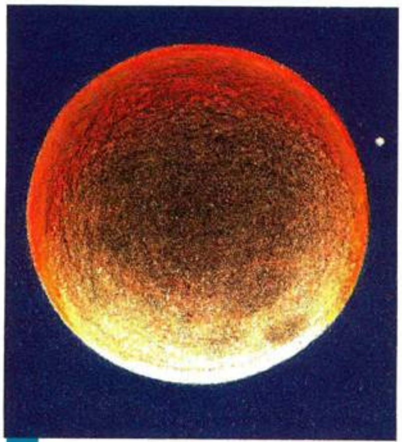
November 28's Total Lunar Eclipse

by Alan Dyer
(4-inch f/6 refractor, ScotchChrome 400 film, 45-second exposure on November 28, 1993)



Jupiter's Great Red Spot

by Viktor A. Zinoviev
(40mm refractor at 217x, sketch made on November 11, 1991)



The Moon in Eclipse

by Jorge Ivan Cerritos Chacon
(7x50 binoculars, sketch made on November 28, 1993)

"The total lunar eclipse of November 28/29 was one of the best visible in many years," says Brenda Culbertson of Harveyville, Kansas, a small town near Topeka. A group from Culbertson's local club, the Northeast Kansas Amateur Astronomers' League, ventured out to see Earth's shadow wash across the Moon as the lunar disk hovered gracefully between the Hyades and Pleiades clusters in Taurus.

A group of members including Culbertson, Julee Fisher, David Costales, and Gary Hug observed the eclipse from Harveyville. "During totality the Moon displayed a sliver of slightly brighter light along its southern limb," says Culbertson. "Because of the reddish color it looked like a cherry hanging in the sky."

Some members soaked up the visual treat offered by the eclipse while others recorded the event on film. "It was fascinating to watch the Moon slowly move in front of several bright stars," says Roger Heaton. Equipped with two cameras fitted with 70mm and 135mm lenses, Roy Herrman systematically photographed the Moon as it darkened during the early stages of the eclipse and brightened during the later ones. Heaton also shot the Moon at the prime focus of his 8-inch SCT and made multiple exposure images of the Moon's changing face.

Postcards from Russia. ASTRONOMY rarely sees observations from amateur astronomers in the former Soviet Union. So it was a special treat when recently we received a group of superb observations of Jupiter from Viktor A. Zinoviev of Volgograd, Russia. Zinoviev uses 30mm and 40mm Zeiss refractors at a variety of powers to make disk drawings and strip sketches of Jupiter's changing cloud features. His artistic skill shows in the careful plotting of small belts, bands, and festoons — detail often not visible in backyard photographs of the mighty planet's face.

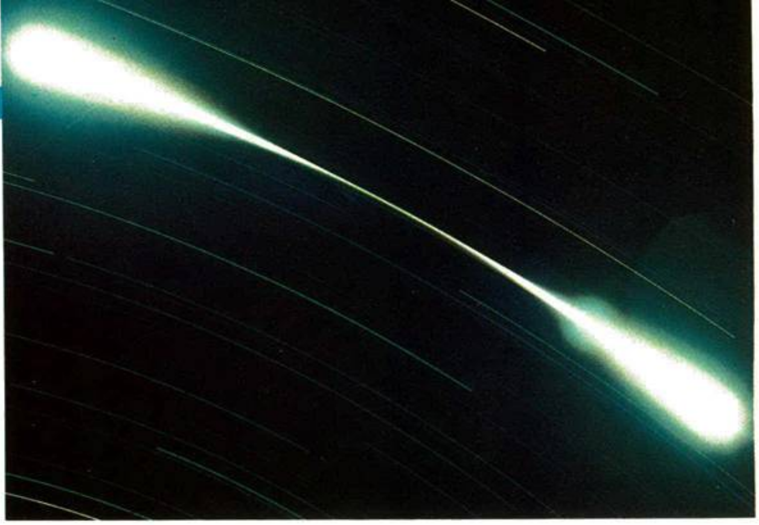
Nova Cassiopeiae Reports. On December 7, 1993, Syuichi Nakano of Matsue, Shimane, Japan, discovered a bright nova on a photograph he had taken of the constellation Cassiopeia. Designated Nova Cassiopeiae 1993, the star was estimated by its discoverer to shine at magnitude 6.5. Nakano confirmed the discovery on December 11. Two days later Arizona amateur Peter Collins independently found the object and estimated its brightness at magnitude 6.0. The nova's position is 23h41m47s, +57°31'02" (epoch 2000).

Michael Boschat of Halifax, Nova Scotia, observed the nova with 7x50 binoculars and estimated its brightness at magnitude 5.5 on December 17 and 6.0 on December 18. Quebec amateur Dominique Beauchamp observed the star in mid-December and produced a light curve showing the nova dimming to magnitude 7 by December 19. □

ASTRONOMY wants to hear about your observations of the sky. Send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187. Please label each photograph submission with your name, address, and social security number. You may send written reports via Internet at: 72000.2704@CompuServe.COM.

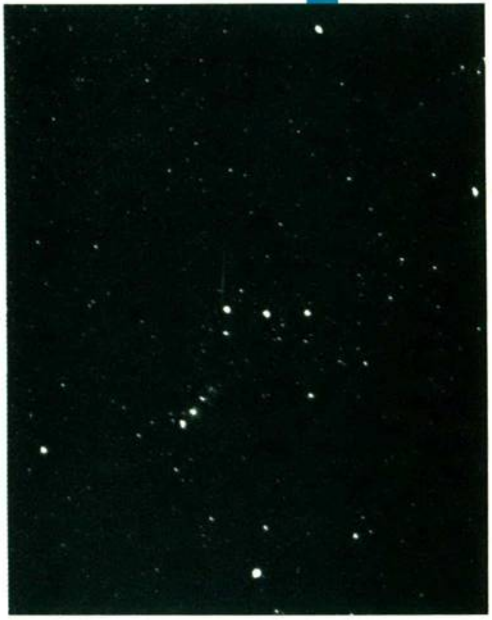
The Lunar Eclipse of November 28/29, 1993

by Jerry Schad
(35mm lens at f/5.6,
Kodachrome 64 film)



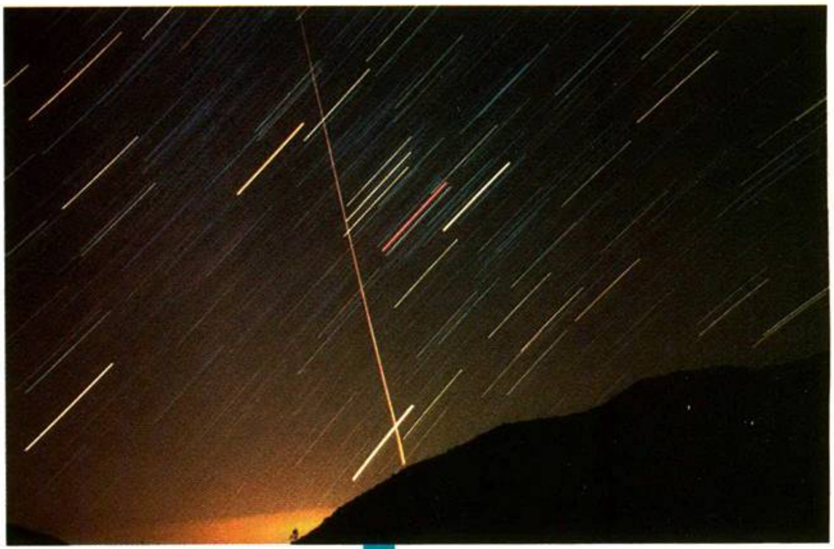
A Geminid Meteor Loosens Orion's Belt

by Jay Edwards
(50mm lens at f/2, taken
on December 14, 1993)



THE SUN'S SPECKLED FACE

Viewed or photographed in visible light, the Sun's surface seems relatively tranquil. Seen in the hydrogen-alpha wavelength, however, the face of the Sun transforms into a speckled surface. Sunspots, plages, and granulation cover the Sun's sphere in Giovanni dal Lago's H-alpha portrait (opposite page), which wins this month's $100 "Best Astrophoto" award.

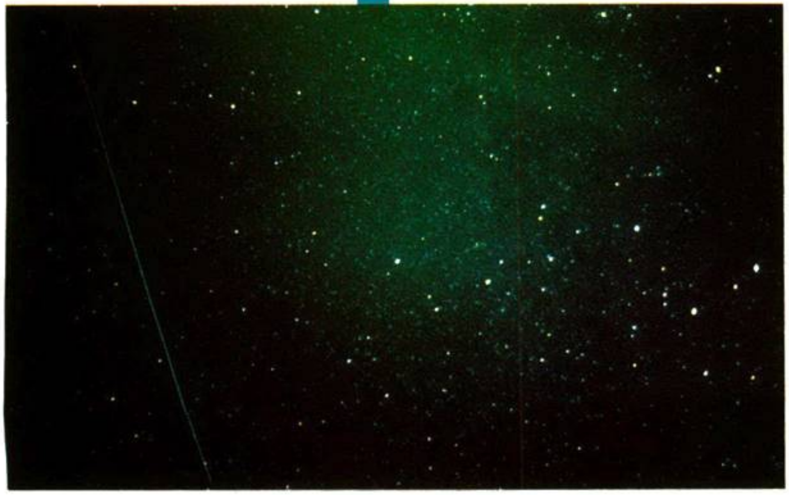


Orion Hosts a Geminid Fireball

by Chris Cook
(24mm lens at f/5.6, ScotchChrome
400 film pushed to ISO 800, 45-minute
exposure on December 10, 1993)

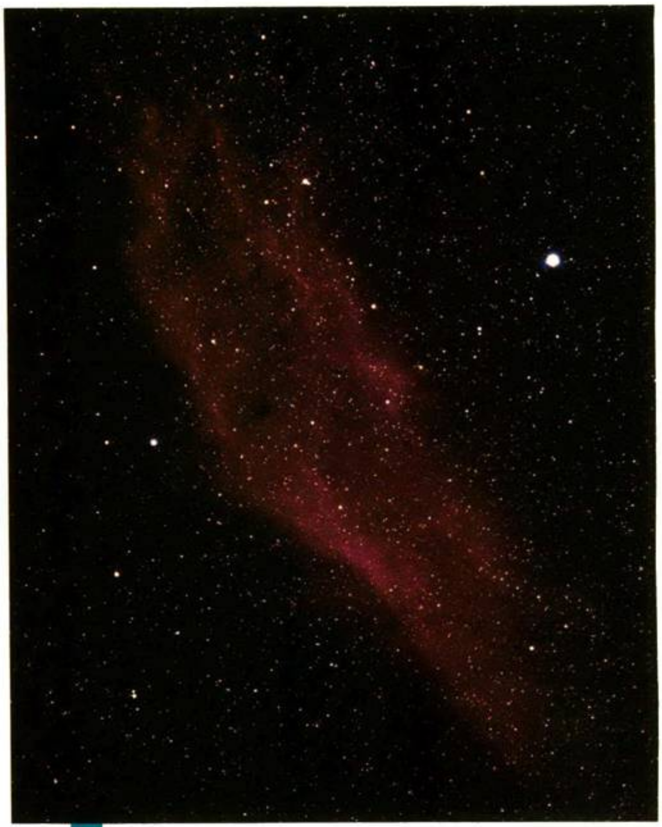
An Orionid Meteor Splits Pyxis

by Wallace Baldwin
(taken on October 21, 1993)



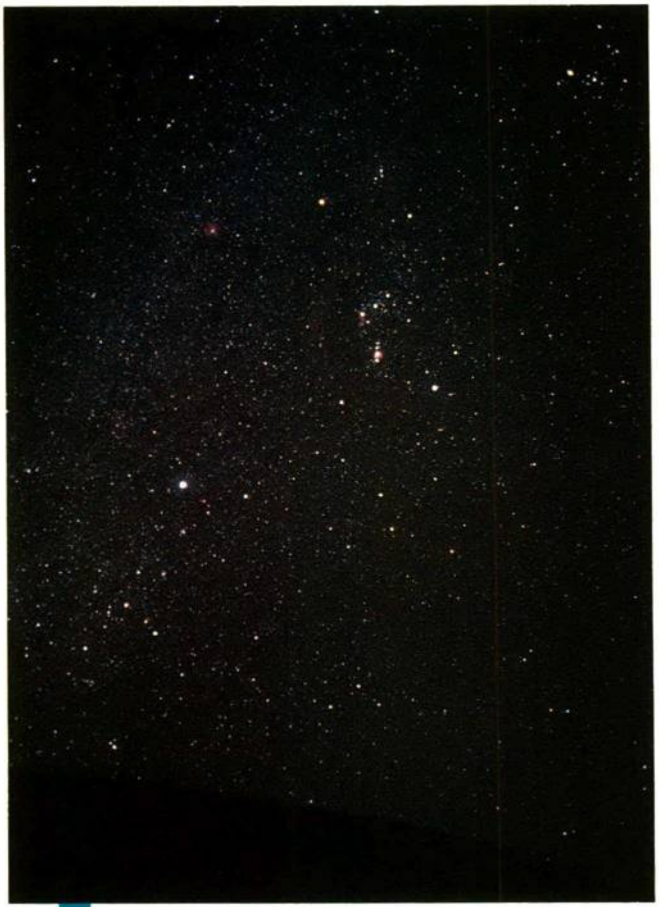
The Sun in Hydrogen-Alpha

by Giovanni dal Lago
(11-inch SCT at f/6.3, Tech Pan
film, taken with a hydrogen-alpha
filter on October 3, 1993)



The California Nebula in Perseus

by George Greaney
(6-inch f/7.1 refractor, hypersensitized Fuji Super HG 400 film, composite of two 50-minute exposures)

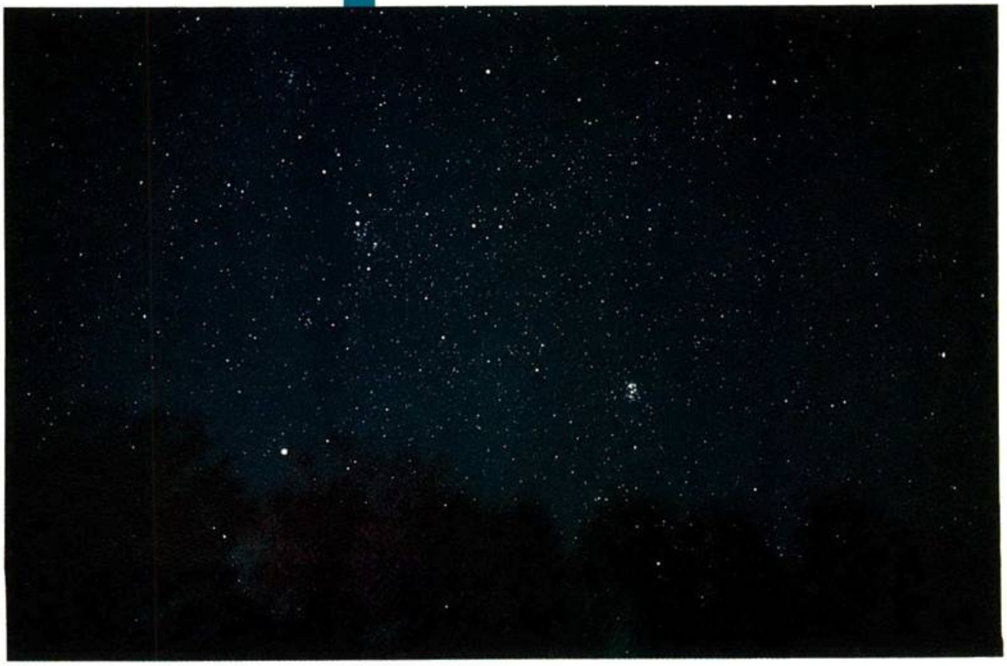


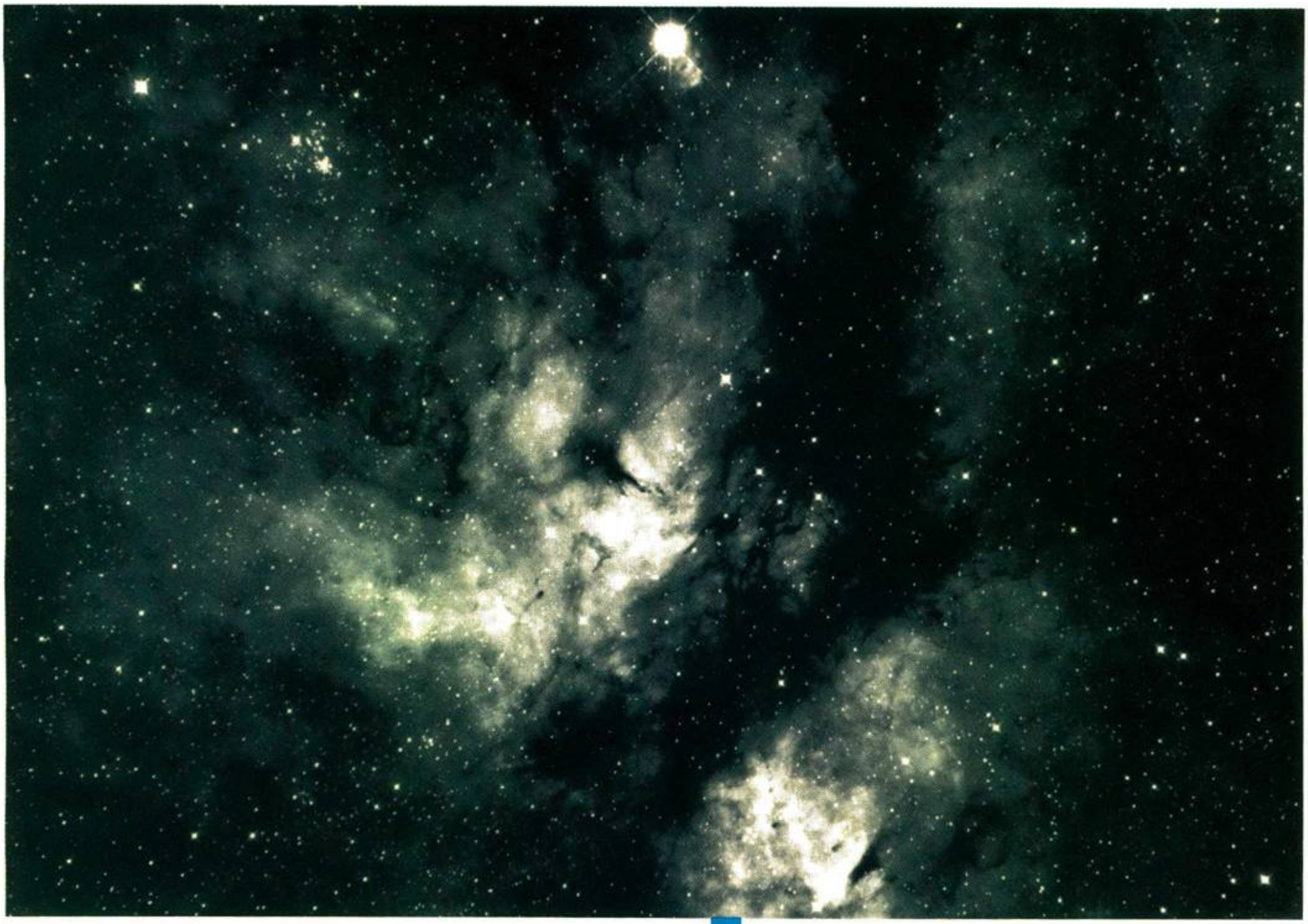
Orion and the Winter Milky Way

by Chris Cook
(24mm lens at f/2.8, ScotChrome 400 film pushed to ISO 800, 10-minute exposure)

Auriga, Taurus, and Perseus

by Carl Milazzo
(24mm lens at f/2.8, Fuji 1600 ISO film, 10-minute exposure)





Nebulosity Surrounding Gamma Cygni

by Chuck Vaughn
(7.9-inch hyperbolic astrograph, hypersensitized Tech Pan film, 120-minute exposure using an H-alpha filter)

Open Cluster M7 in Scorpius

by Luke Dodd
(4.7-inch refractor at f/5.6, hypersensitized Fuji Super HG 400 film, 30-minute exposure)

The Double Cluster in Perseus

by Preston S. Justis
(10-inch f/6 reflector, hypersensitized Tech Pan film, 80-minute exposure)

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Aperture	Mounted	Aperture	Unmounted
2.4"	$49.00	2.4"	$39.00
3.1"	52.00	3.1"	42.00
3.5" to 4"	59.00	3.5 to 4"	49.00
4-1/4" to 5"	74.00	4-1/4" to 5"	64.00
6"	79.00	6"	69.00
8"	95.00	8"	85.00
10"	109.00	10"	99.00
11"	119.00	11"	109.00
12.5" to 13.1"	149.00	12.5" to 13.1"	129.00
14"	169.00	14"	149.00

40mm to 80mm Binoculars - Mounted .... $92.00 pr.

GLASS (Full Aperture) Type 2

Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
4-1/4" to 5"	96.00	4-1/4" to 5"	86.00
6"	105.00	6"	95.00
8"	125.00	8"	109.00
10"	139.00	10"	129.00
11"	149.00	11"	139.00
12.5" to 13.1"	179.00	12.5" to 13.1"	159.00
14"	199.00	14"	179.00

40mm to 80mm Binoculars - Mounted .... $115.00 pr.

GLASS (Full Aperture) Type 3

Coated to a neutral density of 4 for serious astrophotographers who desire the shortest possible shutter speeds with slow films. Solar image and optical quality same as type 1 & type 2. Type 3 filters are for photographic use only.

Aperture	Mounted	Aperture	Unmounted
2.4"	$79.00	2.4"	$65.00
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3.5" to 4"	99.00	3.5 to 4"	79.00
4-1/4" to 5"	125.00	4-1/4" to 5"	110.00
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8"	159.00	8"	139.00
10"	172.00	10"	152.00
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2-5/8" x 4-5/8" Overall size .... $2.00 ea.

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Starlight Instruments, Inc., P.O. Box 68282, Schaumburg, IL 60168-0282, (708) 980-9595. $250; 2-inch to 1.25-inch adapter; Schmidt-Cassegrain adapter: $20; color anodizing (blue, red, green, gold): $30.

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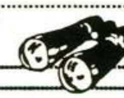

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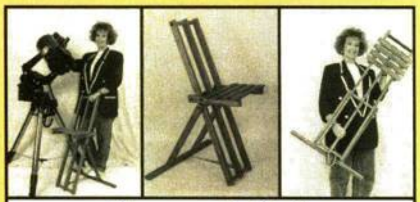

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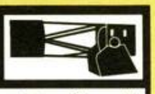

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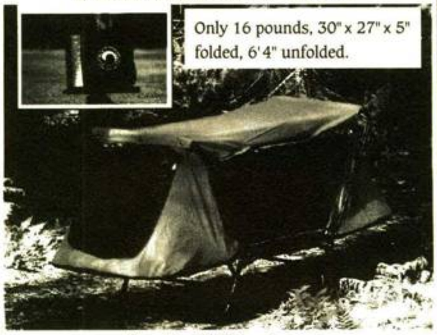

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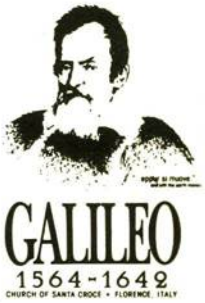
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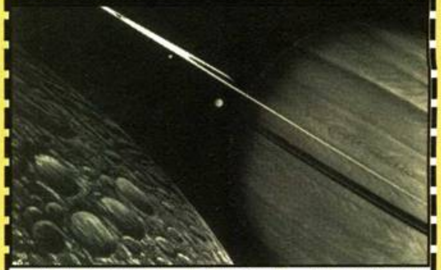

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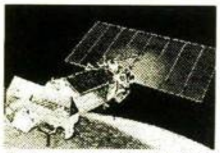

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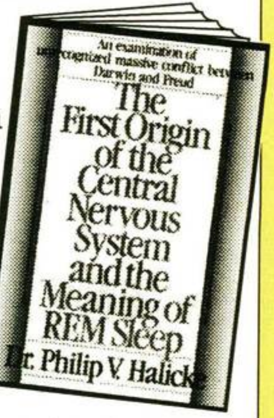
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Viewing the Night Sky

Astronomical Calendar 1994

Guy Ottewell, (Astronomical Workshop, Furman University, Greenville, SC 29613,1993), ISBN 0-934546-28-2, 74 pages, softcover, $16 plus $3 for shipping.

This 11 by 15 inch annual guide to the heavens is a favorite of naked-eye and binocular observers. It provides monthly star maps and tells where to find the planets. Other sections show 3-D views of the orbital paths of planets and comets, describe meteor showers, list recent spaceflights, plot the orbits of bright binary stars, and indicate which asteroids observers can see through binoculars. The section on eclipses shows the path through the United States of the May 10 annular eclipse of the Sun and the expected view of the eclipsed Sun from a number of large cities across the United States and in Canada.

The Monthly Sky Guide

Ian Ridpath and Wil Tirion, (Cambridge University Press, 1993), ISBN 0-521-44865-4, 64 pages, softcover, $14.95.

Ridpath and Tirion's collection of monthly star maps is now in its third edition. It includes information for each month about planetary positions (through 1997), meteor showers, and skylore for prominent constellations. Introductory material explains star names, stellar magnitudes, the use of the maps, and methods for finding one's way around the sky.

The Southern Sky Guide

David Ellyard and Wil Tirion, (Cambridge University Press, 1993), ISBN 0-521-42839-4, 82 pages, softcover, $19.95.

Twenty-four whole sky charts show the constellations as they appear at two-week intervals throughout the year. Each map contains keys to 20 detailed charts showing deep-sky objects visible in binoculars and small telescopes. The introduction explains star names, astronomical terms such as magnitudes, and the use of the sky charts. It also contains a table of planetary positions for 1993 through 1997.

The Explorers of Mars Hill 1894-1994

William Lowell Putnam, (Phoenix Publishing, 1994; available from Lowell Observatory, 1400 West Mars Hill Road, Flagstaff, AZ 86001, (602) 774-3358), ISBN 0-914659-69-3, 304 pages, hardcover, $30.

This tribute combines a description of scientific research at Lowell Observatory and humorous anecdotes to capture 100 years of pioneering exploration at the observatory and the diverse personalities who made it happen. Putnam is the current trustee of the observatory, following the family line of trustees instituted by Percival Lowell in his will. He provides a privileged look behind the scenes at historic discoveries through the years, such as Vesto Slipher's first measurements of receding velocities of distant galaxies in 1912, the finding of Pluto in 1930, the detection of Uranus' rings in 1977, and the glimpse of Pluto's hazy atmosphere in 1988.

Using rare photographs and family and observatory archives, Putnam takes the reader back in time, tracing how Lowell Observatory has grown from the dream of one determined astronomer to the largest privately operated, non-profit astronomical research observatory in the world. The book begins with the story of eccentric founder Percival Lowell, who built the observatory in 1894 to catch a view of Mars while it passed close to Earth. A Harvard mathematician and a man of passionate conviction, Lowell wanted to find proof of intelligent life on Mars, so he jumped into the fray of speculation about canals on Mars in the early 1900s, publishing numerous articles and three books on the subject. He stirred up enough controversy among astronomers, the press, and the public to earn himself a permanent place in history books.

More quietly, Lowell launched research on other projects at his new observatory, including the pursuit of a ninth planet. His extensive calculations convinced him that a Planet X existed beyond Neptune and laid the groundwork for Clyde Tombaugh's discovery of Pluto at the observatory. To augment his story of the observatory and its staff, Putnam includes genealogies and other appendices of interest to history buffs.
— *Marisa Brown*

Ripples in the Cosmos

Michael Rowan-Robinson, (W. H. Freeman, 1993), ISBN 0-7167-4503-8, 224 pages, hardcover, $22.95.

The Infrared Astronomical Satellite mapped the distribution of galaxies in space and put to rest the idea of a Great Attractor that pulled all nearby galaxies toward it. As Rowan-Robinson (an IRAS team member) explains, IRAS showed that several clusters of galaxies tug on our Galaxy with the overall direction toward the Virgo, Hydra, and Centaurus clusters, not an invisible Great Attractor. He links the IRAS observations with those made by the Cosmic Background Explorer of the ripples in the cosmic background radiation. These ripples in the cosmos let us trace the structure of the universe back to 300,000 years after the Big Bang and probe how galaxies formed.

Cosmic Questions

Richard Morris, (John Wiley and Sons, 1993), ISBN 0-471-59521-7, 200 pages, hardcover, $24.95.

Ten questions provide the framework of Morris' thoughtful probe into our universe. His queries include Did the Big Bang really happen? (he concludes yes), Is space infinite? When did time begin? What is the universe made of? What is nothingness like? What is time? and How will the universe end? Although scientists don't yet have answers for all these questions, Morris provides the current thinking and physical evidence regarding each topic. A glossary helps beginners with physical and astronomical terms.

Astronomy: A Self-Teaching Guide

Dinah Moché, (John Wiley and Sons, 1993), ISBN 0-471-53001-8, 347 pages, acid-free paper, softcover, $16.95.

Now in its fourth edition, this self-teaching guide presents the scientific concepts of astronomy in a straightforward way and provides questions — and answers — to help readers test their knowledge. Moché has updated the book throughout and describes the cosmos from the Sun and planets to the most distant quasars.

Resources of Near-Earth Space

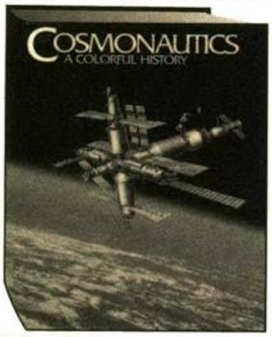
J. Lewis, M. S. Matthews, M. L. Guerrieri, editors, (University of Arizona Press, 1993), ISBN 0-8165-1404-6, 977 pages, acid-free paper, hardcover, $75.

Future space exploration and needs on Earth may require that the Moon, near-Earth asteroids, and perhaps even Mars be mined for their mineral deposits. This collection of 33 articles written by 86 scientists explores the feasibility of this enterprise.

Third Decennial US-USSR Conference on SETI

G. Seth Shostak, editor, (Astronomical Society of the Pacific, 1993), ISBN 0-9337707-66-X, 444 pages, hardcover, $44.50.

Although these are the proceedings from a conference on the search for extraterrestrial intelligence held in California in 1991, many of the 41 articles are accessible to the general reader wanting to know more about the search for other planets, SETI programs such as SERENDIP (named after a tale by Horace Walpole), and the steps one takes after finding an intelligent signal. ☐



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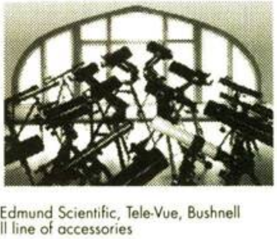

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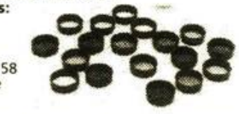

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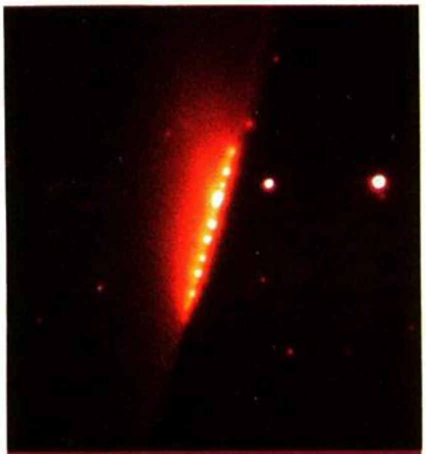

Jane Luu, University of California, Berkeley

COMING IN THE JUNE 1994 ISSUE OF ASTRONOMY

WHEN THE COMET STRIKES JUPITER

Astronomers eagerly await Comet Shoemaker-Levy 9's collision with Jupiter to see what nature's probe can tell them about the giant planet.

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READINGS & CREDITS

Ashes to Ashes Dust to Dust (page 40)

"Proto-Planetary Nebulae" by Sun Kwok in the *Annual Review of Astronomy and Astrophysics* (Annual Reviews, 1993). A good survey of the characteristics of planetary nebula progenitor stars and their early stages of mass loss.

"Astrophysical Gasdynamics Confronts Reality: The Shaping of Planetary Nebulae" by Adam Frank and Bruce Balick, *Astrophysical Journal*, February 10, 1993. The authors present technical simulations comparing computer models with observed planetary nebulae in the sky.

"Fast, Low-Ionization Emission Regions and Other Microstructures in Planetary Nebulae" by Bruce Balick, Martin Rugers, Yervant Terzian, and Jayaram Chengalur, *Astrophysical Journal*, July 10, 1993. The principal technical paper exploring the nature of these baffling features in many planetaries.

Planetary Nebulae; a Practical Guide and Handbook for Amateur Astronomers by Steven J. Hynes (Willmann-Bell, 1991). Includes a basic overview of planetaries and an extensive catalog along with tips and techniques on observing them with backyard telescopes.

May's Ring of Fire (page 92)

"Sunblock" by Jay Anderson, ASTRONOMY, February 1994. Details weather prospects for the path of the May 1994 annular eclipse across North America.

Annular Eclipse of 10 May 1994 by Fred Espenak and Jay Anderson, (NASA Reference Publication 1301, 1993). Gives maps and tables detailing the track of the annular eclipse and weather prospects along the track as well as local circumstances for the partial phases visible from North America, Europe, and Africa.

Cover: Bill and Sally Fletcher; **p. 4, top left:** Tom Bullock; **top right:** Darla Evans; **bottom:** Bruce Balick/NOAO; **p. 18, left:** David Adler and David Westphal/NRAO; **right:** NRAO and Palomar Observatory; **p. 20, top:** F. Paresce (ESA) and R. Jedzejewski (STScI)/NASA; **bottom:** D. Macchetto, ESA, STScI/ NASA; **p. 22:** Rik Hill; **p. 24:** NOAO; **p. 28, top:** Sandra Faber, Lick Observatory/NASA; **bottom:** mysterious unknown credit; **p. 30:** Robert Fugate, Air Force Phillips Laboratory; **pp. 32-35:** General Dynamics; **pp. 36-37:** Pat Rawlings, SAIC; **pp. 38-39:** Pat Rawlings, LPI; **pp. 40-41:** Bruce Balick/NOAO; **p. 42, top:** Bruce Balick/NOAO; **bottom:** Adam Frank/University of Minnesota; **pp. 43-47:** Bruce Balick/NOAO; **pp. 50-51:** National Radio Astronomy Observatory; **pp. 55-78:** all screen images by Darla Evans; **p. 55:** National Optical Astronomy Observatories; **pp. 72-73:** Deannea Dagilis; **p. 80:** Dewey Vanderhoff; **p. 81:** Richard Pomeroy; **p. 83:** David Burt; **p. 84:** H. A. Weaver and T. E. Smith, STScI/ NASA; **pp. 92-93:** A. Bormanis; **p. 94:** Lyle Fischer; **p. 95, top:** Phil Kirchmeier; **bottom:** James Glenn Pearson; **p. 98, bottom:** Duruty Jesus de Alba M.; **p. 100:** Tony and Daphne Hallas; **p. 101:** Chris Schur; **p. 102, left and middle**: Robert Burnham; **right:** John Love; **p. 103, left and right:** Alan Dyer; **bottom:** Chris Schur; **p. 104, bottom left:** Robert Burnham; **top left:** Kevin Jones; **top right:** David Healy; **bottom right:** David J. Eicher; **p. 105, left and middle:** Alan Dyer; **bottom:** Robert Burnham; **p. 106, bottom and top left:** Robert Burnham; **top right:** Bryan White; **p. 107:** Robert Burnham; **p. 113, top:** Alan Dyer, 4-inch f/6 refractor, ScotchChrome 400 film, 45-second exposure on November 28, 1993; **bottom left:** Viktor A. Zinoviev, 40mm refractor at 217x, sketch made on November 11, 1991; **bottom right:** Jorge Ivan Cerritos Chacon, 7x50 binoculars, sketch made on November 28, 1993; **p. 114, top left:** Jay Edwards, 50mm lens at f/2, taken on December 14, 1993; **right center:** Chris Cook, 24mm lens at f/5.6, ScotchChrome 400 film pushed to ISO 800, 45-minute exposure on December 10, 1993; **top right:** Jerry Schad, 35mm lens at f/5.6, Kodachrome 64 film, taken on November 28/29, 1993; **bottom left:** Wallace Baldwin, taken on October 21, 1993; **p. 115:** Giovanni dal Lago, 11-inch SCT at f/6.3, Tech Pan film, taken with hydrogen-alpha filter on October 3, 1993; **p. 116, top left:** Chris Cook, 24mm lens at f/2.8, ScotchChrome 400 film pushed to ISO 800, 10-minute exposure; **top right:** George Greaney, 6-inch f/7.1 refractor, hypersensitized Fuji Super HG 400 film, composite of two 50-minute exposures; **bottom:** Carl Milazzo, 24mm lens at f/2.8, Fuji 1600 ISO film, 10-minute exposure; **p. 117, top:** Chuck Vaughn, 7.9-inch f/4 hyperbolic astrograph, hypersensitized Tech Pan film, 120-minute exposure using an H-alpha filter; **center:** Luke Dodd, 4.7-inch refractor at f/5.6, hypersensitized Fuji Super HG 400 film, 30-minute exposure; **bottom:** Preston S. Justis, 10-inch f/6 reflector, hypersensitized Tech Pan film, 80-minute exposure; **p. 130:** Jane Luu, University of California, Berkeley.

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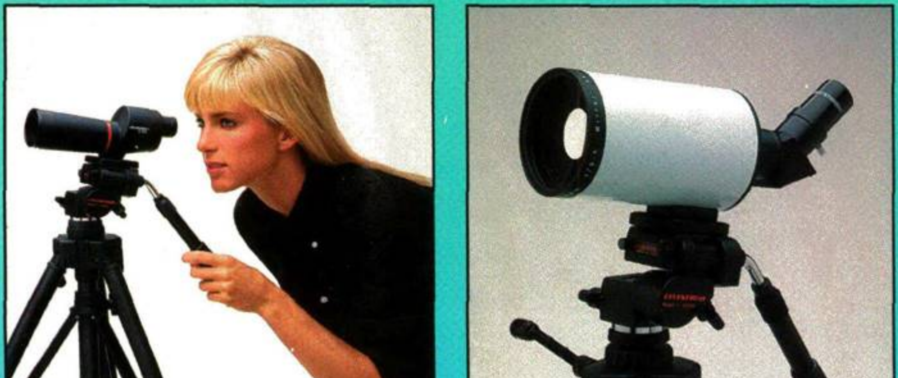

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